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REFORMED SCHOOLS.

Now that college students can rival the ignoble crowd with bat and oars, university culture may be safely advanced another stage, looking to the day when the collegian shall compete with the outsider in other practical branches of knowledge. We deprecate the modern, almighty dollar theory of an exclusively "business" education; we would not *substitute* the most polished scholarship in discount and bookkeeping for the grand old university literature, classical and polite.

The old idea that classical knowledge is an aim and end of education, was, perhaps, more nearly correct than the later idea that classical culture is the only suitable and proper means of working and developing the mind. In this utilitarian age of speculation and greed, of sensational literature, sharp practice and vulgar show, the greatest amount of old fashioned scholarly culture that we can force upon our young men and women will hardly neutralize the leveling tendencies of the times.

But while our schools should not ignore polite culture, they certainly should not neglect practical education. Under the theory that the mind is a machine to be developed, or a power to be disciplined, rather than a storehouse to be filled, are we not overlooking the advantages of positive, technical knowledge? Our new school professors indeed proceed upon the *theory* that the mind can be as well disciplined by practical as by classical studies. But are modern studies practical? Are the greater number of modern English text books really more available to the graduate who has a living and a name to win, than the old Latin ones? There must be one-idea scholars in every branch of knowledge, but are the sublimated mathematics of our "practical" schools either a better universal digester or a better universal resource than Greek roots? If not, then the old fashioned studies have equal advantages in the matter of culture, and the additional dignity of age and scholarly association.

We believe that a comparison of the knowledge wanted in the practical world, with the knowledge furnished in the practical schools, will convince the candid inquirer, 1st. that the course of study is not always well selected; and 2d—and of this we wish particularly to speak—that the books, lectures, references and prescriptions in the departments of learning that purport to be practical and of immediate and every day value, are incomplete and inadequate.

Immediately upon his graduation, in whatever direction his tastes, ambition or necessities may lead him, the young man encounters the *business formulæ* of commerce and production, of which he is ignorant. He may be versed in the elements of political economy, mathematics and chemistry, but he has still to master the rules and forms of practice. He may know the principles of communication with the world, but he has yet to learn the dialects and idioms of business. Mere muscular Training is not more essential to success in athletic sports than mere mental Culture to the triumphs of mind; but Skill plucks the laurels from their brows on the world's playground as well as in the world's workshop. The Latin salu-

tatorian and the Greek versifier of the ancient university, are not much greener than the graduates of "practical" schools when they come to grapple with the first year's work in a business office. This state of things is unnecessary and wrong in every regard. Study is not less a mental tonic because it fits a man to keep books, to write business papers and to buy or make good machinery. And the notorious greenness of graduates in practical affairs, deters many young men from commencing with a theoretical education. It is a grave question in many minds whether skill and training in the arts of life should not precede and lead up to a knowledge of the sciences.

The argument against the dead languages as a means of mental training, when the world is full of live subjects equally difficult to master, is just as valid against practical subjects when taught in an unpractical manner. A man may study mathematics all his life and not be able to earn his bread in a merchant's office or an engineer's drawing room. He may even master all the text books in mechanics and not be able to construct an economical steam engine. We are deceived by the names and cheated of the substance of practical learning. Our universities may well copy the course of training in our *commercial* colleges and our foremost *technical* schools, and so adorn a scholarship that will pay, with the graces of polite and classical culture. At least let us not abandon the studies that not only disciple the mind but liberalize the sentiments and refine the social and intellectual relations of life, until we are prepared to substitute studies that really teach men how to live and thrive—studies that directly and immediately advance the battle of mind against matter—studies that are practical in substance as well as in name.

BLACK LEAD, which has only been used as a lubricator for wooden machinery, and for wood piston packing, is now applied by M. Deloris, in France, to every kind of machine, from the heaviest vehicles to the most delicate watch-work, so dispensing with the use of oils and grease of all kinds. If plumbago can be successfully applied to railway carriages, a great saving to the companies will be effected. It is said to be used with many vehicles in Paris, and in machinery at several factories, and seems to give satisfaction.

PAPERS ON CONSTRUCTION.

No. IV.

IRON ROOFS.

By Lieut. C. E. DUTTON.

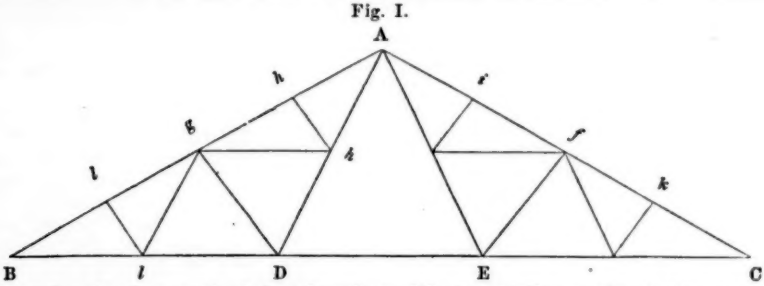
(Continued from page 583.)

A roof owes its stability to a series of similar frames called trusses. The most common form of roof-truss is an isosceles triangle, of which the two equal sides supporting the roof covering are called principal rafters. The rafters are subject to compressive and transverse stress, and are constructed accordingly. The third side is subject only to tensile stress, and is called the tie-rod, or tie-beam, and, in the case of an iron roof, consists of one or more rods of round iron. The stresses which this truss is required to withstand are, 1st, those arising from the weight of the entire roof structure, and 2d, those caused by the weather, viz: wind and snow. For the resistance to these forces the rafter may be treated as an inclined beam supported at each end, and, if desirable, at intermediate points, the lower end abutting against the extremity of the tie-rod, and the upper end against the upper end of the opposing rafter.

The rafters are made either of common rolled T iron, or of two pieces of L, or angle-iron, riveted in such a manner that they form a T. The flange is placed upwards for several reasons, that being the position of gratest strength in a beam of that particular cross-section, besides being most convenient for the attachment of purlins, braces and struts. The tie-rod has a jaw at each end, which receives the web of the rafter to which it is pinned.

In roofs of great span, in order to give the rafter the requisite rigidity, secondary trussing must be resorted to. But in such a case the general principle of the truss is in no respect changed, the variations being merely those of detail and supplementary. The two rafters and the tie-rod still remain, but with the addition of new parts for carrying out the same general design. To secure proper stiffness the rafter is supported in the middle by a strut, which thrusts against a point held in stable equilibrium by two or more forces, whose resultant is equal and opposite to the thrust. Fig. I is a compound truss of the commonest form. The junction of each part will readily suggest itself upon a simple inspection of the diagram.

Fig. I.



Assuming that in a roof of given length, measured along the ridge, the rafters are placed at equal distances apart, the weight of superstructure to be sustained by each will be equal to the weight of material between any two consecutive rafters. To this must be added the weight of the rafter itself, with its appurtenances, and a suitable calculation should be made of the maximum amount of snow which may accumulate upon it, and of the force of the wind. Of these the weight of the rafter is an unknown quantity. The others may be readily determined after the pitch, or slope of the roof, is decided upon.

To determine the stress upon the various parts.—Let W represent the weight of a section of the roof between two consecutive principles. Each rafter will then support one half this weight. The mutual support afforded at the apex is transmitted to the walls at B and C, so that each wall sustains one-half the load. Although the load is uniformly distributed, we may consider it as concentrated at A with a vertical resultant $= \frac{1}{2}$ W. This resultant may be resolved into two components acting along the rafters A B and A C with forces $= \frac{1}{2}(\frac{1}{2}$ W cosec $\phi)$, in which expression ϕ represents the angle of the slope of the roof. Since cosec. $= \frac{R}{\text{sin.}}$ we may put the expression for the thrust into the following form: $t = \frac{1}{4}\,\frac{W}{\text{sin. }\phi}$ This thrust is opposed by two forces, one of which is the upward resistance of the wall; the other, the pull of the tension rod. Hence we may divide it into two components, r' and r.

$$r' = t \text{ sin. } \phi = \tfrac{1}{4}\,\frac{W}{\text{sin. }\phi} \text{ sin. } \phi = \tfrac{1}{4} W$$

$$r = t \text{ cos. } \phi = \tfrac{1}{4}\,\frac{W}{\text{sin. }\phi} \text{ cos. } \phi = \tfrac{1}{4}\,\frac{W}{\text{tan. }\phi}.$$

In the equation $r' = \frac{1}{4}$ W, only half the weight is actually considered, viz: that portion which is directly supported at the apex and transmitted by the thrust of the rafters to the top of the wall. But each wall supports directly $\frac{1}{4}$ W, which, added to the quantity obtained, makes $\frac{1}{2}$ W, which represents the entire supporting force of each wall.

The stresses sustained by the minor component parts of a compound truss must be determined separately, and for this purpose we must ascertain the distribution of the load over the points B, l, g, h, A. Since $\frac{1}{2}$ W is equally distributed over each rafter we may consider B l, l g, g h, h A, as so many separate, uniformly loaded beams, resting upon their respective points of support, with stresses equal to $\frac{1}{16}$ W at each end, so that the direct stresses as thus considered are, at A and B $\frac{1}{16}$ W each, and at l, g, h, $\frac{1}{8}$ W each. But the stresses at l and h are transmitted through the struts $l\,l'$, $h\,h'$ to their respective suspending rods (braces), and by the braces to the points B, g, A. A simple inspection of the diagram will show that the resultant of the pulls along $g\,h'$ and $g\,l'$ will be equal to $\frac{1}{8}$ W along g D. This stress, added to the direct stress at g, gives $\frac{1}{4}$ W for the total stress at that point. The tension along $g\,h'$ and A h', $g\,l'$ and B l' is, in each case, $\frac{1}{16}\,\frac{W}{\text{sin. }\phi}$ cos. ϕ. By the same reasoning it will appear that the tension along B D and D A must be $\frac{1}{8}\,\frac{W}{\text{sin. }\phi}$ cos. ϕ. It has already been shown that the tension along B C, due to the primary thrust of the abutting rafters, is $\frac{1}{4}\,\frac{W}{\text{sin. }\phi}$ cos. ϕ. Hence the pull along B l is $\frac{W}{\text{tan. }\phi}$ $(\frac{1}{4} + \frac{1}{8} + \frac{1}{16})$; the pull along l D is $\frac{W}{\text{tan. }\phi}$ $(\frac{1}{4} + \frac{1}{8})$, and the pull along D E is $\frac{W}{\text{tan. }\phi}$ $(\frac{1}{4})$.

It is apparent that the braces produce a compressive stress in the rafter in addition to the direct thrust caused by the weight of the opposing rafter. A g D and B g D may be considered as triangles of forces in equilibrium. By taking one-half the weight imposed upon the strut g D $\frac{1}{8}$ W, we have at once the means of determining the forces acting upon the other sides of each triangle. It has already been shown that the pulls along A D and B D are $\frac{1}{8}\frac{\text{W}}{\text{tan. }\phi}$, and the compression of the rafter due to these two pulls must be $\frac{1}{8}\frac{\text{W}}{\text{tan. }\phi}\cos.\phi = \frac{1}{8}\frac{\text{W}}{\text{sin. }\phi}$ In the same way it may be shown that the compression produced by the braces A h' and g h', g l' and B l' is $\frac{1}{16}\frac{\text{W}}{\text{sin. }\phi}$. Hence the total compression is

$$\text{P} = \frac{\text{W}}{\text{sin. }\phi}\left(\tfrac{1}{4} + \tfrac{1}{8} + \tfrac{1}{16}\right).$$

The pressures upon the struts g D and l l' are respectively $\frac{1}{8}$ W and $\frac{1}{16}$ W.

Many trusses are constructed with the tie-rod raised above the horizontal, as in Fig. II.

Fig. II.

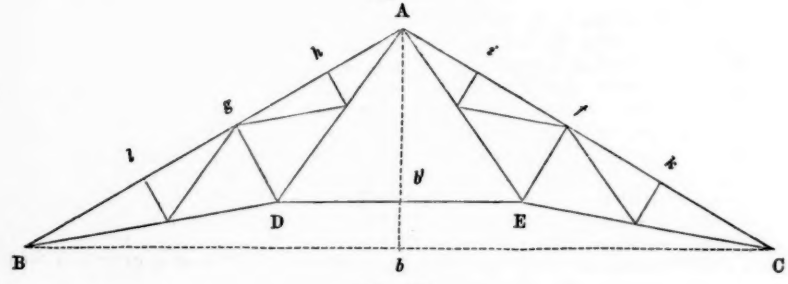
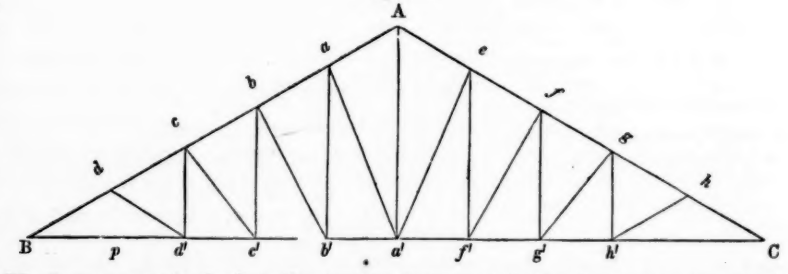


Fig. III.



We have ascertained that the tension on a rod from B to C would be $t = \frac{1}{4}\frac{\text{W}}{\text{tan. }\phi}$. An inspection of the diagram will show that the tension on the rod D E will always vary inversely, as its perpendicular distance from A, *i. e.* tension on B C: tension on D E:: A b': A b. The tension on the braces may be formed as before.

An excellent method of trussing, and one very extensively employed in England for moderate spans, is shown in Fig. III. It is known as the king and queen post truss, a a', b b', c c', &c., are struts, and a b', b c', c d', &c., are suspension rods, and their arrangement is such that B d' c, B c' b, B b' a, &c., may be considered as braces holding each its own strut. Assuming, as in the first example, that B d, d c, c b, &c., are separate beams, each supported at its extremities, then (assuming also that there are four secondary trusses), the distribution of the load is as follows: $\frac{1}{5}$ the weight of the rafter, or $\frac{1}{10}$ W, rests directly on each of the points a, b, c, d, and $\frac{1}{20}$ W on A σ B. By means of the braces and struts one-half the weight at d is transmitted to c, $\frac{2}{3}$ the weight at c to b, $\frac{3}{4}$ the weight at b to a, and $\frac{4}{5}$ the weight at a to A. If we resolve the thrust along any one one of the struts, for instance b b', into the two components which withstand it, viz: b' c' and c' b, the former will represent the additional pull on the tie rod, and the latter the pull on the queen-

post $a\ b'$ caused by the stress at b'. Treating the stresses at the other points in the same manner, we shall find that they all give rise to equal additional pulls on the tie-rod. But the pull on the tie-rod produced by the strut $d\ d'$ is $\frac{1}{20} \cdot \frac{W}{\text{tan. } \phi}$. Hence the tensions on the tie-rod are

Between $a'\ b' = \frac{W}{\text{tan. } \phi}\ (\frac{1}{4} + \frac{1}{20})$.

" $b'\ c' = \frac{W}{\text{tan. } \phi}\ (\frac{1}{4} + \frac{2}{20})$.

" $c'\ d' = \frac{W}{\text{tan. } \phi}\ (\frac{1}{4} + \frac{3}{20})$.

" $d'\ B = \frac{W}{\text{tan. } \phi}\ (\frac{1}{4} + \frac{4}{20})$.

and the tensions on the queen-posts are,

on $c\ d' = \frac{1}{10}\ W$

$b\ c' = \frac{3}{20}\ W$

$a\ b' = \frac{1}{5}\ W$

$A\ a' = \frac{1}{2}\ W$.

The king post $A\ a'$, it will be observed, receives the stresses from two struts—$a\ a'$, $e\ a'$.

The few illustrations we have given contain the main principles involved in the operation of forces upon the frame work of triangular roofs of moderate size. The variations of detail may be almost infinite, and they are sometimes very complicated, but are easily reducible to simple thrusts and pulls, and to parallelograms of forces.

In iron roofs the trusses described are made to serve the purposes of both principal and common rafters. The distances between them may vary, according to circumstances, from 3 ft. to 30 ft. In the latter case, and in all cases where a considerable interval between rafters is desirable, the purlins must be trussed. The foot of the rafter may be received into a cast-iron saddle bolted to the wall plate, and the main tie-rod may be jawed and riveted to the web of the rafter, or may pierce the casting and be fastened by a key or pin, or thread and nut. These matters of minor detail are always highly variable and are determined simply by considerations of convenience. In this climate and latitude, provision should be made for varying the length of the main tie to adapt it to the wide ranges of temperature, and this is best accomplished by a swivel-nut in the center.

The purlins are bars of iron, crossing the rafters at right angles, and to them the roof covering is directly attached. The most suitable form is ordinarily a double flanged bar or rail, of such a length that its ends shall rest upon rafters.

The roof covering may be wood or iron. In the former case it is shingled or tiled, and in the latter corrugated iron is by far the best material. Corrugated iron may be obtained in sheets of any length not exceeding 8 ft., and the length of the sheets should be a multiple of the length of the rafter, added to the proper allowance for overlaps. Thus, a rafter 27 ft. long will require four lengths of 7 ft., 4 in. being allowed for each of the three overlaps. But the lateral joints would present a difficulty if the plates or sheets were of uniform length, since, in that case, the intersection of a lateral and terminal joint would involve the superposition of the corners of four sheets, which must be avoided by breaking joints in alternate courses. Hence a certain proportion of the sheets (easily determined by the circumstances of the case) should be ordered of extra length and an equal number of inferior length. In the case supposed of a 27 ft. rafter, one 8 ft. and one 6 ft. plate should be ordered for every six plates of 7 ft. The junction at the ridge is best effected by a cast-iron covering, sloping in both directions for a few inches, and with its edges corrugated to fit the surfaces of the plates, and overlapping them a few inches. This casting should be made of the best iron in the most accurate manner and of the least thickness consistent with sound casting. Openings for ventilators may be left in them if desirable. The plates should be prepared, before laying them, with a good coating of mineral paint, in which oxide of iron is a principal constituent.

We introduce a portion of an article by Mr. J. J. Birckel, published in the London "Artizan," upon the accidental stresses to which a roof may be subjected. "Among the accidental sources of pressure, wind and snow form the most important items, because both may occur simultaneously. According to General Morin's observations, snow may accumulate to the depth of 20 in., and as its weight is $\frac{1}{10}$th that of water, the pressure due to this element would be about 11 lbs. per square ft. The same philosopher, however, thinks that one-half this amount will make ample provision. We will keep on the safe side, and suppose it to be 6 lbs. per square ft. Respecting the wind, we subjoin a short table of the pressures produced at various speeds upon a plane of resistance supposed to be at right angles with the direction of the wind:

Speed in ft. per second.	Pressure per sq. ft.	Speed in ft. per second.	Pressure per sq. ft.
ft. in.		ft. in.	
10 0	0.2	46 0	4.7
13 9	0.6	65 7	9.6
26 3	1.5	131 0	38.4
35 7	2.8		

General Morin, from whose work the above data are quoted, thinks that a direct pressure of 3 lbs. per square ft. is quite sufficient to reckon upon; but English engineers differ from him on this point, and make allowance for a pressure of 7 or 8 lbs. per ft." [In this country, where tornadoes are not unfrequent, this allowance should be still greater, though the chief danger to be apprehended from such disasters is the access of the wind to the underside of the roof, through windows and elsewhere.] "In the following tables we give the items of permanent pressure due to the covering, and to the structure of the roof itself, which, added to the items previously defined, will make up the whole weight, which must form the basis of calculation of the strength of the roof:

Nature of Covering.	Weight in lbs. per sq. ft.
Common tiles	13
Hollow tiles	16 to 18
Slates	8
Rolled copper	3
Zinc	2
Galvanized sheet iron	2
Corrugated sheet iron	2¼
Asphalte	5¼

Table of Weights of Principals and Purlins.

Distance between principals	Span.	Weight of principal.	Weight of purlins for one bay.	Weight per sq. ft. of roof' g.
ft. in.	ft. in.	lbs.	lbs.	lbs.
6 6	26 0	137	225	2.03
6 6	40 0	337	290	2.20
6 6	65 9	888	418	2.87
6 6	82 0	1,668	482	3.80
9 10	26 0	194	508	2.59
9 10	40 0	502	653	2.76
9 10	65 9	1,387	943	3.39
9 10	82 0	2,625	1,088	4.34
13 1	26 0	245	959	3.33
13 1	40 0	580	1,233	3.26
13 1	65 9	1,705	1,781	3.81
13 1	82 0	2,755	2,055	4.22

Mean weight per sq. ft. 3.22 lbs.

Observations.—These data are quoted from Gen. Morin's work; principals supposed to be trussed as per diagram No. 2; their weight has been increased by the amount of one-fourth for deficiency in rafters; angle of roof about 25°.

If, now, we sum up the pressures arising from the various sources enumerated, we shall find that the loads per square foot, for different kinds of covering, are as follows:

Nature of Covering.	Weight in lbs. per sq. ft.
Common tiles	33
Hollow tiles	29
Slates	28
Rolled copper	23
Zinc	22
Galvanized sheet iron	22
Corrugated sheet iron	22½
Asphalte	27¾

The load of 40 lbs. per sq. ft., which is generally taken by English engineers as a basis in the calculation of roofs, is by no means exaggerated, though it may be quite sufficient.

Aero-Steam Engines.—Some interesting trials of Warsop's air and steam engine have been for some time in progress at Nottingham; and the report upon the results has been made by a well-known and, in such matters, very painstaking London engineer. The engine, being started by steam in the ordinary manner, a single-acting air pump, worked from the crank-shaft, compresses air to a little more than the boiler pressure, the air thus passing through a long circuit of straight and coiled pipe, which traverses the exhaust pipe, makes several spiral coils in the chimney, then descends at one side of the firebox, exposed to the full fire, and finally connects with a valve-box, through which the air, more or less heated, enters the boiler at the bottom of the water space. So far as the experiments—carefully made upon an imperfect engine, worked alternately with steam alone and with steam and air—can be taken as establishing a principle, they indicate a considerable economy—an economy, however, beyond anything which, as yet, is inferable from theory. Further experiments upon a new and greately improved engine on Warsop's system are arranged to take place very shortly, when the results will be laid before our readers.—*Engineering.*

REMARKABLE ENDURANCE OF BESSEMER STEEL AXLES.

The following table gives in detail, the tests of several steel axles, taken at random from a number of axles made by the Pennsylvania Steel Company, out of their regular product of Bessemer steel.

The first test shows, probably, the most remarkable endurance on record, viz: bending backward and forward under a ton drop falling forty-six times from a height of 16½ feet, and twelve times from a height of 18 feet, the axle being reversed after each blow, and the total deflection back and forth being 163 inches.

TESTS OF BESSEMER STEEL AXLES *made at the Pennsylvania Steel Works, Baldwin, near Harrisburgh, Pa., May,* 1869.

[Weight of drop 2,000 lbs. V shaped wrought iron tup. Bearings 3 feet apart on cast iron supports.]

No. of blow.	He'ght of fall.	DEFLECTION.—INCHES. Before blow.	After blow.	Effect of blow.	Total.
	ft. in.				
1	16 6	— .00	⌣ 3.44	3.44	3.44
2	do	⌒ 3.44	— .00	3.44	6.88
3	do	— .00	⌣ 3.06	3.06	9.94
4	do	⌒ 3.06	— .00	3.06	13.
5	do	— .00	⌣ 2.88	2.88	15.88
6	do	⌒ 2.88	— .00	2.88	18.75
7	do	— .00	⌣ 3.	3.	21.75
8	do	⌒ 3.	— .00	3.	24.75
9	do	— .00	⌣ 3.	3.	27.75
10	do	⌒ 3.	— .00	3.	30.75
11	do	— .00	⌣ 3.	3.	33.75
12	do	⌒ 3.	— .00	3.	36.75
13	do	— .00	⌣ 2.75	2.75	39.5
14	do	⌒ 2.75	— .00	2.75	42.25
15	do	— .00	⌣ 3.	3.	45.25
16	do	⌒ 3.	— .00	3.	48.25
17	do	— .00	⌣ 3.19	3.19	51.44
18	do	⌒ 3.19	— .00	3.19	54.62
19	do	— .00	⌣ 3.12	3.12	57.75
20	do	⌒ 3.12	— .00	3.12	60.88
21	do	— .00	⌣ 3.12	3.12	64.
22	do	⌒ 3.12	— .00	3.12	67.12
23	do	— .00	⌣ 3.19	3.19	*70.31
24	do	⌒ 3.19	⌣ .25	3.44	73.75
25	do	⌒ .25	⌣ 3.12	3.38	†77.12
26	do	⌒ 3.12	⌣ 1.	4.12	†81.25
27	do	⌒ 1.	⌣ 1.	2.	83.25
28	do	⌒ 1.	⌣ 1.5	2.5	85.75
29	do	⌒ 1.5	⌣ 1.	2.5	88.25
30	do	⌒ 1.	⌣ 1.38	2.38	90.62
31	do	⌒ 1.38	⌣ 1.25	2.62	93.25
32	do	⌒ 1.25	⌣ 1.5	2.75	96.
33	do	⌒ 1.5	⌣ 1.12	2.62	98.62
34	do	⌒ 1.12	⌣ 1.62	2.75	101.38
35	do	⌒ 1.62	⌣ 1.12	2.75	104.12
36	do	⌒ 1.12	⌣ 1.5	2.62	106.75
37	do	⌒ 1.5	⌣ .88	2.38	109.12
38	do	⌒ .88	⌣ 1.62	2.5	111.62
39	do	⌒ 1.62	⌣ .88	2.5	114.12
40	do	⌒ .88	⌣ 1.75	2.62	116.75
41	do	⌒ 1.75	⌣ .88	2.62	119.38
42	do	⌒ .88	⌣ 1.75	2.62	122.
43	do	⌒ 1.75	⌣ .88	2.62	124.88
44	do	⌒ .88	⌣ 1.62	2.5	127.12
45	do	⌒ 1.62	⌣ .75	2.38	129.5
46	18	⌒ .75	⌣ 1.62	2.38	131.88
47	do	⌒ 1.62	⌣ 1.	2.62	134.5
48	do	⌒ 1.	⌣ 1.75	2.75	137.25
49	do	⌒ 1.75	⌣ 1.25	3.	140.25
50	do	⌒ 1.25	⌣ 1.75	3.	143.25
51	do	⌒ 1.75	⌣ 1.5	3.25	146.5
52	do	⌒ 1.5	⌣ 1.75	3.25	149 75
53	do	⌒ 1.75	⌣ .88	2.62	152.38
54	do	⌒ .88	⌣ 1.75	2.62	155.
55	do	⌒ 1.75	⌣ .88	2.62	157.62
56	do	⌒ 88	⌣ 1.75	2.62	160.25
57	do	⌒ 1.75	⌣ 1.	2.75	163.
58	do	⌒ 1.	———	broke.	
1	16 6	— .00	⌣ 2.88	2.88	2.88
2	do	⌒ 2.88	— .00	2.88	5.75
3	do	— .00	⌣ 2.5	2.5	8.25
4	do	⌒ 2.5	— .00	2.5	10.75
5	no	— .00	⌣ 2.5	2.5	13.25
6	do	⌒ 2.5	— .00	2.5	15.75
7	do	— .00	⌣ 2.5	2.5	18.25
8	do	⌒ 2.5	— .00	2.5	20.75
9	do	— .00	⌣ 2.5	2.5	23.25
10	do	⌒ 2.5	— .00	2.5	25.75
11	do	— .00	⌣ 2.62	2.62	28.38
12	do	⌒ 2.62	— .00	2.62	31.
13	do	— .00	⌣ 2.75	2.75	33.75
14	do	⌒ 2.75	— .00	2 75	36.5
15	do	— .00	⌣ 2.62	2.62	39.12
16	do	⌒ 2.62	— .00	2 62	41.75
17	do	— .00	⌣ 2.75	2.75	44.5
18	do	⌒ 2.75	— .00	2.75	47.25
19	do	— .00	⌣ 2.75	2.75	50.
20	do	⌒ 2.75	— .00	2.75	52.75
21	do	— .00	⌣ 2.75	2.75	55.5
22	do	⌒ 2.75	— .00	2.75	58.25
23	do	— .00	⌣ 1.75	1.75	60.
24	do	⌒ 1.75	⌣ 1.25	3.	63.
25	do	⌒ 1.25	⌣ 1.5	2.75	‡65.75
26	do	⌒ 1.5	⌣ 1.38	2.88	‡68.62
27	do	⌒ 1.38	⌣ 1.25	2.62	71.25
28	do	⌒ 1.25	⌣ 1.5	2.75	74.
29	do	⌒ 1.5	⌣ 1.38	2.88	76.88
30	d6	⌒ 1.38	⌣ 1.	2.38	79.25
31	do	⌒ 1.	⌣ 1.5	2.5	81.75
32	do	⌒ 1.5	⌣ 1.5	3.	‡84.75
33	do	⌒ 1.5	⌣ 1.25	2.75	‡87.5
34	do	⌒ 1.25	⌣ 1.62	2.88	90.38
35	do	⌒ 1.62	⌣ 1.12	2.75	93.12
36	do	⌒ 1.12	⌣ 1.5	2.62	§95.75
37	do	⌒ 1.5	⌣ 1.25	2.75	§98.5
38	do	⌒ 1.25	⌣ 1.5	2.75	101.25
39	do	⌒ 1.5	———	broke.	

* Turned ¼ over between 23d and 24th blows, as axle was bent sidewise by 23d blow.

† Turned ¼ over for same reason, between 25th and 26th blows.

* A little crack about ¼ in. × 1-16 in. opened on *under side*, about 1¼ in. from point struck on top side.

† This crack was struck and closed up.

‡ Same crack opened a little wider.

§ Crack keeps opening.

No. of blow.	He'ght of fall.	DEFLECTION.—Inches. Before blow.	After blow.	Effect of blow.	Total.
	ft. in.				
1	16 6	— .00	⌣ 2.	2.	2.
2	do	⌒ 2.	— .00	2.	4.
3	do	— .00	⌣ 2.	2.	6.
4	do	⌒ 2.	.38	2.38	8.38
5	do	⌒ .38	⌣ 1.75	2.12	10.5
6	do	⌒ 1.75	.38	2.12	12.62
7	do	⌒ .38	⌣ 1.88	2.25	14.88
8	do	⌒ 1.88	.5	2.38	17.25
9	do	⌒ .5	⌣ 1.75	2.25	19.5
10	do	⌒ 1.75	.5	2.25	21.25
11	do	⌒ .5	⌣ 1.62	2.12	23.88
12	do	⌒ 1.62	⌣ .5	2.12	26.
13	do	⌒ .5	⌣ 1.75	2.25	28.25
14	do	⌒ 1.75	⌣ .38	2.12	30.38
15	do	⌒ .38	⌣ 1.75	2.12	32.5
16	do	⌒ 1.75	⌣ .38	2.12	34.62
17	do	⌒ .38	⌣ 1.62	2.	36.62
18	do	⌒ 1.62	⌣ .38	2.	38.62
19	do	⌒ .38	⌣ 1.75	2.12	40.75
20	do	⌒ 1.75	⌣ .5	2.25	43.
21	do	⌒ .5	⌣ 1.62	2.12	45.12
22	do	⌒ 1.62	⌣ .5	2.12	47.25
23	do	⌒ .5	⌣ 1.75	2.25	49.5
24	do	⌒ 1.75	⌣ .38	2.12	51.62
25	do	⌒ .38	⌣ 1.62	2.	53.62
26	do	⌒ 1.62	⌣ .38	2.	55.62
27	do	⌒ .38	⌣ 1.62	2.	57.62
28	do	⌒ 1.62	⌣ .38	2.	59.62
29	do	⌒ .38	⌣ 1.75	2.12	61.75
30	do	⌒ 1.75	⌣ .38	2.12	63.88
31	do	⌒ .38	⌣ 1.75	2.12	66.
32	do	⌒ 1.75	⌣ .5	2.25	68.25
33	do	⌒ .5	⌣ 1.75	2.25	70.5
34	do	⌒ 1.75	⌣ .38	2.12	72.62
35	do	⌒ .38	⌣ 1.62	2.	74.62
36	do	⌒ 1.62	⌣ .38	2.	76.62
37	do	⌒ .38	⌣ 1.75	2.12	78.75
38	do	⌒ 1.75	⌣ .25	2.	80.75
39	do	⌒ .25	⌣ 1.75	2.	82.75
40	do	⌒ 1.75	⌣ .5	2.25	85.
41	do	⌒ .5	⌣ 1.62	2.12	87.12
42	do	⌒ 1.62	⌣ .38	2.	89.12
43	do	⌒ .38	⌣ 1.62	2.	91.12
44	do	⌒ 1.62	⌣ .5	2.12	93.25
45	do	⌒ .5	⌣ 1.75	2.25	95.5
46	do	⌒ 1.75	———	broke.	
1	do	— .00	⌣ 2.88	2.88	2.88
2	do	⌒ 2.88	— .00	2.88	5.75
3	do	— .00	⌣ 2.5	2.5	8.25
4	do	⌒ 2.5	— .00	2.5	10.75
5	do	— .00	⌣ 2.5	2.5	13.25
6	do	⌒ 2.5	— .00	2.5	15.75
7	do	— .00	⌣ 2.5	2.5	18.25
8	do	⌒ 2.5	— .00	2.5	20.75
9	do	— .00	⌣ 2.5	2.5	23.25
10	do	⌒ 2.5	— .00	2.5	25.75
11	do	— .00	⌣ 2.5	2.5	28.25
12	do	⌒ 2.5	— .00	2.5	30.75
13	do	— .00	⌣ 2.62	2.62	33.38
14	do	⌒ 2.62	— .00	2.62	36.
15	do	— .00	⌣ 2.56	2.56	38.56
16	do	⌒ 2.56	— .00	2.56	41.12
17	do	— .00	⌣ 2.75	2.75	43.88
18	do	⌒ 2.75	— .00	2.75	46.62
19	do	— .00	⌣ 2.75	2.75	49.38
20	do	⌒ 2.75	— .00	2.75	52.12
21	do	— .00	⌣ 2.5	2.5	54.62
22	do	⌒ 2.5	— .00	2.5	57.12
23	do	— .00	⌣ 2.62	2.62	59.75
24	do	⌒ 2.62	— .00	2.62	62.38

No. of blow.	He'ght of fall.	DEFLECTION.—Inches. Before blow.	After blow.	Effect of blow.	Total.
	ft. in.				
25	16 6	— .00	⌣ 2.75	2.75	65.12
26	do	⌒ 2.75	— .00	2.75	67.88
27	do	— .00	⌣ 2.75	2.75	70.62
28	do	⌒ 2.75	.00	2.75	73.38
29	do	— .00	⌣ 2.88	2.88	76.25
30	do	⌒ 2.88	.00	2.88	79.12
31	do	— .00	⌣ 2.88	2.88	82.
32	do	⌒ 2.88	.00	2.88	84.88
33	do	— .00	⌣ 2.88	2.88	87.75
34	do	⌒ 2.88	.00	2.88	90.62
35	do	— .00	⌣ 2.88	2.88	93.5
36	do	⌒ 2.88	———	broke.	
1	do	— .00	⌣ 2.88	2.88	2.88
2	do	⌒ 2.88	— .00	2.88	5.75
3	do	— .00	⌣ 2.56	2.56	8.31
4	do	⌒ 2.56	— .00	2.56	10.88
5	do	— .00	⌣ 2.5	2.5	13.38
6	do	⌒ 2.5	— .00	2.5	15.88
7	do	— .00	⌣ 2.38	2.38	18.25
8	do	⌒ 2.38	— .00	2.38	20.62
9	do	— .00	⌣ 2.25	2.25	22.88
10	do	⌒ 2.25	— .00	2.25	25.12
11	do	— .00	⌣ 2.31	2.31	27.44
12	do	⌒ 2.31	— .00	2.31	29.75
13	do	— .00	⌣ 2.5	2.5	32.25
14	do	⌒ 2.5	— .00	2.5	34.75
15	do	— .00	⌣ 2.31	2.31	37.06
16	do	⌒ 2.31	— .00	2.31	39.38
17	do	— .00	⌣ 2.5	2.5	41.88
18	do	⌒ 2.5	— .00	2.5	44.38
19	do	— .00	⌣ 2.38	2.38	46.75
20	do	⌒ 2.38	— .00	2.38	49.12
21	do	— .00	⌣ 2.5	2.5	51.62
22	do	⌒ 2.5	— .00	2.5	54 12
23	do	— .00	⌣ 2.38	2.38	56.5
24	do	⌒ 2.38	— .00	2.38	58.88
25	do	— .00	⌣ 2.38	2.38	61.25
26	do	⌒ 2.38	— .00	2.38	63.62
27	do	— .00	⌣ 2.62	2.62	66.25
28	do	⌒ 2.62	— .00	2.62	68.88
29	do	— .00	⌣ 2.62	2.62	71.5
30	do	⌒ 2.62	— .00	2.62	74 12
31	do	— .00	⌣ 2.75	2.75	76.88
32	do	⌒ 2.75	———	broke.	

NO CRACKS OR FLAWS.

1	do	— .00	⌣ 2.88	2.88	2.88
2	do	⌒ 2.88	— .00	2.88	5.75
3	do	— .00	⌣ 2.5	2.5	8.25
4	do	⌒ 2.5	— .00	2.5	10.75
5	do	— .00	⌣ 2.62	2.62	13.38
6	do	⌒ 2.62	— .00	2.62	16.
7	do	— .00	⌣ 2.62	2.62	18.62
8	do	⌒ 2.62	— .00	2.62	*21.25
9	do	— .00	⌣ 2.62	2.62	23.88
10	do	⌒ 2.62	— .00	2.62	26.5
11	do	— .00	⌣ 2.75	2.75	29.25
12	do	⌒ 2.75	— .00	2.75	32.
13	do	— .00	⌣ 2.62	2.62	34.62
14	do	⌒ 2.62	— .00	2.62	37.25
15	do	— .00	⌣ 2.62	2.62	39.88
16	do	⌒ 2.62	— .00	2.62	42.5
17	do	— .00	⌣ 2.5	2.5	45.
18	do	⌒ 2.5	———	broke.†	

* Turned 1-16th over so as to hit squarely; turned back after next blow.

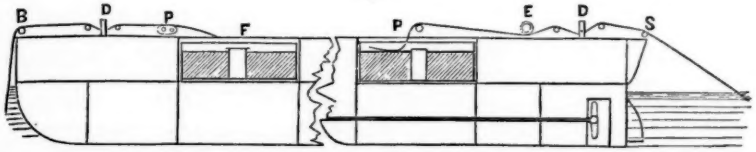
† At point where struck, 2 small longitudinal surface cracks at under side, at time of last blow.

THE FRENCH ATLANTIC CABLE.

From "The Engineer."

In another column will be found a summary of a very interesting lecture by Mr. Fleeming Jenkin, one of the electricians engaged in the new Atlantic cable expedition, containing much information about the method of laying the French cable. We are indebted to Mr. Jenkin for the accompanying diagrams, which show some of the essential points of the appliances to be used to submerge the cable. Fig. 1 is a section of the Great Eastern, showing the tanks containing the cable, and the position of the paying-out and picking-up machinery; B is the bow-wheel over which the cable is hauled in; D the dynamometer; P the picking-up wheel; and F the fore-tank. The main tank is omitted; P aft-tank; E paying-out drum; D the dynamometer, and S the stern wheel, with the cable running out into the ocean.

Fig. 1.



Figs. 2 and 3 represent the most important part of the paying-out machinery, invented by the late Mr. Appold. Fig. 2 shows the principle of Appold's brake. In this cut O is the pivot of the break-wheel, and C the pivot on which the lever C, A, B works. W is the weight on the brake. The brake-wheel is attached to the paying-out drum. When the friction of the brake strap is greater than the weight W, the latter is lifted up, and as C, A, B is shorter than O, A, B, the change of angle relaxes the brake strap, and lets the wheel slip. In this way the strain on the cable never can exceed that of the weight W. Fig. 3 shows Appold's brake drum. In this cut C is the center on which the lever hangs, to which the weight W is attached, and applies pressure to the strap on the break wheel of the paying out drum. To prevent the weight W from vibrating, there is a piston at P, fitting closely into a cylinder containing water. T is a capstan wheel for lifting up the weight W when the paying-out machinery is entirely released from the brake.

Fig. 2.

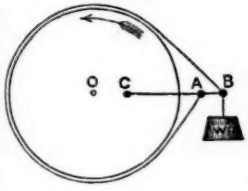


Fig. 4 shows the picking-up catenaries. In the upper part of the cut, M represents the grapnel at the surface of the water, showing the catenary which would be formed by a cable paid out with 14 per cent of slack and lifted in a depth of 2,000 fathoms. In the lower part of the cut, S represents the Great Eastern, and B, M, two auxiliary vessels simultaneously lifting the cable. M is a sharp grapnel intended to cut the cable, and so reduce the strain upon the cable at S.

Fig. 3.

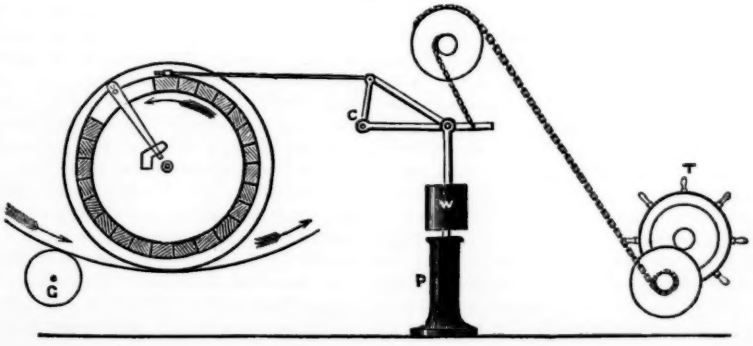


Fig. 4.

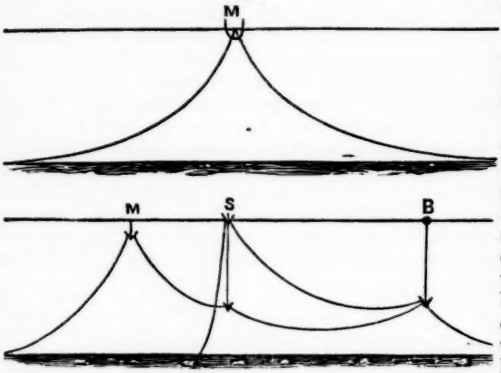
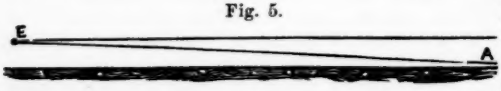


Fig. 5, representing the paying out of the cable, shows the angle at which the cable lies behind the ship in paying out at four knots per hour. E is the Great Eastern, and A the point where the cable reaches the bottom of the ocean, the practical depth of the water being 2,000 fathoms.

The shore ends of the French-Atlantic

Fig. 5.



cable are very heavy, but taper as they reach the deep sea portions. They have the same core as the main cable, and at the end furthest from the shore are each covered with twelve BB galvanized iron wires, .238 in. in diameter, weighing not less than 11,160 lbs. per knot. The heavy shore end next the landing places is first covered with twelve BB galvanized iron wires, nineteen inches in diameter, served with a sufficient quantity of tarred yarn to form a bedding for twelve strands, each formed of three galvanized iron wires .230 inches in diameter, giving a total weight of iron per knot of not less than 38,000 lbs. All the iron wire is of the quality known as "best best," free from inequalities, galvanized, annealed, and capable of being bent round itself and unbent without breaking. There is no weld or joint in any of the iron wires within twelve feet of any other weld. The shore ends are further covered, outside the iron wires, with two coatings of mineral pitch and silica, in the proportions of sixty and forty parts respectively, with sufficient mineral tar to give the requisite consistence, and with two servings of tar hemp yarn, laid alternately, the first coating of yarn being next the wires, then a serving of compound, then the yarn again, and lastly compound. The compound was applied hot and the yarn was laid over immediately afterwards. The yarn is everywhere covered with the compound, so that the outsides of the shore ends are smooth and regular. There are 18 knots of the heaviest shore end, and 127 knots of the lightest shore end; very little of this heavy cable will be laid off the coast of France, but a great deal off St. Pierre. At each end of the deep sea cable there will be a taper a quarter of a mile long, joining it to the shore ends.

The joints in the iron wires are made by scarphing the ends, binding them with fine wires and soldering them, each wire being also served with the best Manilla or New Zealand hemp steeped in tar. The conductor consists of a strand of seven wires of annealed copper, with an electrical resistance per knot at a temperature of 75 deg. Fah. of not more than 3.25 British Association units. The interstices of the strand are completely filled up with Chatterton's compound. The gutta percha insulator is put on in four concentric layers of equal thickness, with a layer of Chatterton's compound between each layer of gutta percha. The electrical resistance of the insulator at 75 deg. Fah. is not less than 250 millions of British Association units after one minute's electrification. The finished core is capable of resisting the passage of water along the conductor, when a pressure of 600 lbs. per square inch is applied at one end of a specimen 6 in. long. Very great precautions have been taken by the manufacturers to prevent faulty joints, for it is at the joints that electrical leakage is most likely to occur. During all processes of manufacture the cable was kept as much as possible under water, and on board the Great Eastern the cable tanks are kept nearly full of water, so that the cable is completely covered.

The main cable from the island of St. Pierre to the United States, is 700 miles long, and will take a very indirect route, because of the inequalities and dangers presented by the bottom of the sea off the eastern coast of America. This cable being shorter and more easily recoverable in case of accident, is not of such good quality as

contains a conducting strand of seven copper wires, weighing 107 lbs. per knot, and the insulator, of gutta-percha and Chatterton's compound, weighs 150 lbs. per knot. This core is served with tanned jute yarn, with a covering of ten BB galvanized wires, .165 in. in diameter, weighing about 4,254 lbs. per knot. It has an outer protection of hemp and asphalte, laid on in two coatings. The shore ends are of the same description as those connected with the main Atlantic cable; in all there are twenty-two knots of the heaviest shore end, and fifty-four knots of the lighter shore end to be used with the main cable connecting St. Pierre with the United States.

In accordance with the terms of the contract between the "Société du Cable Transatlantique Français, Limited," and the Telegraph Construction and Maintenance Company, Limited, the latter will receive in all £920,000 if they lay the whole line successfully, and it keeps in good working order for six months. But the greater portion of the above amount has already been paid to them. The following are the particulars:

First payment		£50,000
3,564 miles of cable at £164 per mile	£584,496	
On completion of manufacture,	504	
		585,000
Seven payments of £20,000 each, when each length of 500 miles was coiled on board		140,000
When the ship leaves Brest		35,000
On completion of the section between Brest and St Pierre (in fully paid shares)		80,000
On completion of the section between St. Pierre and the United States		10,000
Six months after the completion of the whole (in fully paid shares)		20,000
		£920,000

Directly the Great Eastern returns to England she will take fresh cable on board and start for India, to lay a line between Bombay and Suez.

STEEL CASTINGS.—Railway-wheels, anvil-dies, gearing, frogs, and many other heavy parts are now cast by Butcher and other steel makers, at much less than the cost of forgings, and with double the strength and nearly the smoothness of the best iron castings. From our extended experience with steel dies for steam hammers, and with steel gearing, we are prepared to express the belief that steel castings rank among the great economies of the day.

THE SUBMERSION AND RECOVERY OF SUBMARINE CABLES.

CONSTRUCTION OF THE FRENCH ATLANTIC CABLE.

From a paper read before the Royal Institution, by Professor FLEEMING JENKIN, F. R. S.

The speaker began by stating that his object was to explain the principles on which engineers had acted in laying and recovering submarine cables, rather than to exhibit the details of the machinery employed. The general construction of electrical cables was first described, and specimens were shown; especial attention being drawn to the deep sea French Atlantic cable, consisting of the following parts: A copper conductor, gutta-percha insulator, and jute serving, surrounded by ten wires of homogeneous iron, each served with five Manilla yarns saturated with tar.

TABLE I.

Construction of French Atlantic Cable—Deep Sea Section.

	Lbs. weight per knot.	Diameter in inches.	Breaking strain, lb.
Copper	400	.168	644
Gutta-percha	400	.463	...
Serving	284	.669	...
Homo. wires (10)	1,589	.100	950
Manilla strands (50)	1,091	....	550
Each served wire	268	.245	1,550
Cable	3,701	1.134	16,530
Weight of cable in air	1.652 tons per knot.		
" water	.753	"	
Strength in tons	7⅞ tons.		

Table No. 1 gives the dimensions, weights and strengths of each of the component parts. The wire served with hemp will bear a greater weight than the sum of the weights borne separately by the wire and the strands; and, again, the ten served wires, when formed into a rope, bear a greater weight than the sum of the weights which each will bear. Moreover, while the homogeneous iron elongates less than one per cent before breaking, and the hemp elongates only .75 per cent, the two combined stretch 3 per cent. This paradoxical result is due to want of absolute uniformity in the strength of each part; when separate, each breaks at the weakest point; when combined, the weakest points seldom coincide; hence, the strength of the combination is the sum of the mean strengths of the parts, necessarily greater than the sum of the minimum strengths. The so-called spiral or helical form does not really render the cable elastic or liable to stretch, nor does it compress the the one to be laid across the Atlantic. It

core inside the sheathing, as was shown by an experiment where the core was actually withdrawn without causing the collapse of the sheathing.

The manner of coiling the cable on board ship was explained by diagrams and models; it being shown that, in order to avoid putting a twist into the rope when taking it out of the hold, it was necessary to put a twist in when coiling it away. Bad coiling produces kinks or loops drawn tight, which are avoided by a cone filling the eye of the coil, and by rings or equivalent arrangements preventing the bight, as drawn out of the hold, from lashing out under the influence of centrifugal force.

The following table gives the dimensions and contents of the "Great Eastern" tanks as arranged for the Atlantic expedition. These tanks keep the cable under water on board ship to facilitate the electrical tests. They carry a weight of 5,000 tons in a bulk of 180,000 c. ft., the tanks not being filled quite to the top.

TABLE II.

	Diameter.	Depth.	Cable knots.
Fore tank.....	51 ft. 6 in.	20 ft. 6 in.	728
Main tank.....	75 ft. 0 in.	16 ft. 6 in.	1,100
After tank.....	58 ft. 0 in.	26 ft. 6 in.	912

Notwithstanding their enormous weight and size, these tanks occupy a very insignificant proportion of the whole bulk of the "Great Eastern."

Mr. C. W. Siemens has for light cables employed a sort of reel or drum on a turntable, with partial success, instead of the fixed tank and coil. From the tank the cable, when paid out, passes over a pulley and along a trough to the brake drum, the object of which is to restrain the free exit of the cable to such an extent as is desired. The cable is laid hold of by being passed several times round a drum, as a rope making fast a vessel may be seen to be passed round a bollard; the friction allows a slight strain at one end to prevent a very heavy pull at the other end from causing the rope to slip round the drum. The slight pull at what may be called the light end of the rope is given by a series of jockey pulleys which play the part of the hand when the rope is allowed to slip round a bollard, but, in paying out a cable the rope does not slip round a drum; the drum itself turns round restrained by a friction-band or belt.

It is essential that this restraining friction should be constant—a result obtained by the Appold brake, which was explained by models and diagrams. In this arrangement both ends of the brake strap are attached to one lever, in such a manner that when the drum begins to turn it tends to lift the lever and weight hanging to it, and as the lever is lifted it slackens the brake-strap until the difference of tension on the two ends of the strap is equal to the weight hanging on the lever. When this is the case, the lever is no longer lifted, but remains stationary with the strap, allowing the drum to turn, restrained by a constant friction equal to the weight on the lever. If the co-efficient of friction increases, the lever will be a little more lifted and the strap slackened; if the co-efficient of friction diminishes, the lever and weight will fall, tightening the strap; but in any case the retarding force will be simply equal to the weight.

From the brake-drum the rope dips under a weighted pulley, which rides, as it were, suspended on a V of taut cable; if the strain increases, the rope straightens and raises the pulley, if the strain diminishes, the weight and pulley fall; thus the height of the pulley indicates the strain. This instrument is called the dynamometer. Lastly, the rope passes over a pulley into the sea.

Having shown how the cable was treated, the speaker proceeded to show how the strains to be expected could be calculated. A cable paid out in air hangs in a catenarian curve, but in water lies in a straight line, and the strains in the two cases are wholly different. In air the rope meets with no sensible obstacle to its motion, either longitudinally or in a direction perpendicular to its own length; in water, on the contrary, each foot of a cable meets with an opposition to its motion perpendicular to its length, which we may call Q, and for the Atlantic cable

$$Q = .154\ v^2,$$

where v is the velocity of the cable normally to its own length in feet per second. Thus, as the cable weighs .2575 lbs. per ft., it cannot sink faster than the speed given by the equation

$$.2575 = .154\ v_1^{\ 2},$$

from which v_1, the settling velocity, is found to be 1.294 ft. per second, or .765 knot per hour. The result of this resistance to displacement is that the cable lies in a straight line, not in a catenary curve, supported, as it were, by an inclined plane

of water constantly yielding at the velocity v_1. The inclination of the straight line depends on the velocity of the ship and on v_1 not being at all affected by the tension of the rope.

The angle ϕ at which the cable will lie may be calculated as follows: Let P be the resistance of the water to displacement by each foot of the cable of the weight ω when lying at the angle ϕ,

$$P = \omega \cos. \phi;$$

let v_{11} be the velocity at which the cable moves perpendicularly to itself,

$$v_{11} = v \sin. \phi,$$

where v is the velocity of the ship.

$$\text{Also } P = \omega \frac{v_{11}^2}{v_1^2};$$

$$\text{hence, } \cos. \phi = \frac{v_{11}^2}{v_1^2} = \frac{v^2 \sin.^2 \phi}{v_1^2},$$

$$\text{and } v_1 = \frac{v \sin. \phi}{\sqrt{\cos. \phi}}; \quad \ldots 1 \text{ deg.}$$

and, assuming that the resistance is proportional to the square of the velocity, we have $\omega = Q\, v_1^2$, and hence,

$$\frac{\omega}{Q} = \frac{v^2 \sin.^2 \phi}{\cos. \phi}, \text{ or}$$

$$\frac{\omega}{Q v^2} = \frac{\cos. \phi}{\sin.^2 \phi},$$

from which we have

$$\cos. \phi = \frac{\sqrt{\omega^2 + 4 m^2} - \omega}{2 m} \quad \ldots 2 \text{ deg.}$$

where $m = Q\, v^2$.

From this formula, as indeed from common sense, it appears that the greater the value of Q and of v the smaller the inclination with the horizon. The rough Atlantic cable, when the ship was going at the speed of six knots per hour, lay at an angle of $6\frac{3}{4}$ deg., so that the inclined plane was seventeen miles long, and each foot of the cable took nearly three hours to reach the bottom.

The strain T at the top of the inclined plane, if there were no friction preventing the rope from slipping back along the plane, would be equal to the weight of a piece of cable hanging plumb from the surface of the water to the bottom, or

$$T = \omega x,$$

where ω is the weight per foot run of the cable and x is the depth in feet.

But there is a sensible friction which helps to relieve the strain precisely as when a chain is lying on a solid inclined plane; calling m_1 the co-efficient of friction in pounds per foot length of cable at the velocity v in feet per second, and assuming that $m_1 = Q_1 v^2$, the experiment of the Atlantic cable showed that $Q_1 = .00504$ (this is equivalent to .81 cwt. per knot of cable when slack is paid out at the rate of one knot per hour). The result is, that when slack is paid out, say at the rate of one knot per hour, and when $\phi = 6.45$ deg., the strain is diminished by one-half, and if slack were paid out at the rate of 1.4 knot per hour, or $23\frac{1}{2}$ per cent, this particular cable would require no retarding force whatever.

The strain T_1, when the velocity of the cable is v_{111}, can be found from the following formula:

$$T_1 = \omega x - m_1 \frac{\left(\frac{v_{111}}{v} - \cos. \phi\right)^2}{\sin. \phi} x \ldots . 3 \text{ deg.}$$

Cables of light specific gravity have a small settling velocity and lie at great length in the water, and, if they are also rough, the co-efficient Q_1 may easily be so great as to relieve the brake of most of the strain which would be necessary to lay a cable of equal weight but small bulk and smoother surface, with the same amount of slack. If no slack were laid, there would be little difference between the tension required for cables of different construction but of equal weights in water. When much slack is laid, all cables will be considerably less strained than if laid without slack; and, finally, the faster the ship goes the less slack is required to produce any given amount of relief.

The correctness of the above theory has been amply proved in practice. If in seas 2 miles deep the cable hung in a catenary $12\frac{3}{4}$ miles long, the weight to be carried would be $8\frac{1}{2}$ tons, and the strain on the cable 29 tons; while, if the cable hung in a catenary the inclination of which to the horizon at the stern was 9 deg. 30 min., the length would be 24 miles, the weight 17 tons, and the strain 102 tons instead of about 14 cwt.—the strain actually observed for the Atlantic cable when being paid out at 7 knots per hour while the ship was going at 6 knots per hour. The rise and fall of the ship, even in heavy weather, very slightly affects the strain while paying out, on account of the slight inclination of the cable to the horizon. The margin of strength in deep sea cables of the Atlantic type is even greater than is given in most engineering works, since the cable will bear tenfold the strain which is found necessary in laying.

The process of grappling was next de-

scribed, and the operation illustrated, by dragging a miniature grapnel over the floor, so as to hook a chain lying there. When the cable is hooked, the strains of the grapnel rope are simply the weights of the bight lifted, and the length of this bight depends on the slack. Thus, with 14 per cent of slack, the length of the cable lifted will be 4.89 times the depth to which it is raised. Thus, in two miles of water, about 9.8 miles of cable will be lifted, the weight on the grapnel will be 6.86 tons, but the strain on the cable will be only one component of this weight resolved in the direction of the tangent to the curve at the grapnel; this strain will be 5.5 tons. Thus, it is clear, that in calm weather, with 14 per cent slack, the cable can be lifted from a depth of two miles. This was actually done upon one occasion; but owing to the pitching of the ship the cable parted, and we successfully recovered by the obvious device of grappling the cable in two points about 2½ knots apart, and breaking the cable at the point furthest from land; the loose end then hung down over the other grapnel, and it is obvious that by this plan the strain on any cable in any depth can be limited to the simple weight of a length of cable hanging from the surface to the bottom. The Atlantic cables will bear five times the strain due in this manner to two miles of depth, and for this operation the margin of strength is also ample. The cable is hauled in by machinery very similar to that adopted for paying out; the drum being simply turned in the opposite direction by a steam engine, if only a small length is to be picked up. If many miles are required, the cable is transferred to the bow, and hauled up by a double drum to avoid the fleeting necessity on a single drum. The friction on the water during the operation adds to the strain; thus, with the valve of Q_1 previously found, at one mile per hour, the friction per mile would be .81 cwt., adding in a depth of two miles 1.61 cwt. to the strain due to the simple weight; besides this, there is some resistance due to the displacement of the water, by the bight of the rope at the bottom, and some extra weight due to the fact, that the cable hangs in a catenary, not in a straight line. The length of this catenary depends on the rate at which this cable is hauled through the water; but even after allowing for all these things the strength of the cable is from three to four times greater than the strain which, in fair weather, need come on the cable when being picked up from a depth of two miles—a margin of strength not unfrequently adopted even in permanent engineering works.

It was by calculations like these, that before the 1865 cable had been recovered in 1866, the speaker was able to write in "The Times," of August, 1865, "If the cable retain its strength, as it probably will, it can certainly be raised;" and now that experience has confirmed theory, engineers are justified in looking forward with great confidence to the continued prosperity and extension of deep-sea telegraphy. The following tables give some further information as to the French Atlantic cable about to be laid, which will cover fifty acres of ground, being a narrow strip, 3,564 knots long, and a little more than an inch wide.

TABLE III.

Lengths and Weights of Materials used in French Atlantic Cable.

	Knots.	Tons.
Copper wire	24,948	533
Gutta-percha	3,564	549
Jute serving	.....	500
Homo. wire	27,222	1,872
Iron wire	9,941	2,855
Total iron and homo. wires	37,163	4,727
Manilla strands	136,110	1,286
Clark's compound	881	652
Deep-sea cable	2,643	4,366
Shallow-water cable	921	3,881
Total cable	3,564	8,247

TABLE IV.

Lengths of Existing Cables.

	Knots.
Atlantic (two)	3,748
Malta, Alexandria (two)	2,254
Persian Gulf	1,308
Home seas	1,277
Miscellaneous (approximate)	1,350
Total	9,937

THE MAST HOPE DISASTER.—Nearly every railway disaster can be traced to bad or worn-out plant and machinery. But after all the modern refinements of materials and construction have been applied, there come to us, about twice a year, the ghastly details of a wholesale murder by the very refinement of stupidity. A misplaced switch, the absence of a signal behind a stopped train, running into a drawbridge, and, sublimest of all, colliding with a train supposed to be on a siding; this is manslaughter, and must be punished as such. No hidden defects in materials or construction can excuse it.

WHEEL-BASE OF RAILWAY VEHICLES—SAFETY OF THE AMERICAN TRUCK.

Although the practice with our common "spread" truck has been remarkably successful, there appears to be something for English engineers to say on the other side of the question, for instance, the following, from a correspondent of "The Engineer," with reference to an article on railway safety which we have quoted from that journal on another page.

The bogie is, in fact, a means of reducing the wheel-base without reducing the length of carriage-body; and the object of this reduction of wheel-base is to diminish that obliquity of the axles which results from their fixed parallelism. This obliquity, in the case of a four-wheeled truck standing centrally between the rails, is well known to be directly proportional to the length of wheel-base, and the conclusion appears to have been jumped at that the shorter the wheel-base the less the obliquity. But the consideration seems to have been overlooked that this obliquity is liable to an increase from the turning of the truck about the bogie-pin until the diagonally opposite wheels touch the rails with their flanges, and that the angle through which the truck can thus turn is *inversely* proportioned to the wheel-base. It is true that while this increases the obliquity of one axle, it diminishes that of the other; but this is no abatement of the damage, since it is the greatest obliquity of any axle that measures the tendency of the truck to leave the rails or burst the track. And this turning of the truck about the bogie-pin, if it be not brought about by chance oscillations, producing the wriggling or "wobbling" which you describe, is certain to be pushed to its extreme limit in one direction, during the passage of curves, by the action of a couple resulting from the resistance of the wheels to being slipped or skidded as they must be to compensate for the inequality of their paths. Now in English stock coupled tightly together, not only are the chance oscillations checked and absorbed by opposing the mass of one carriage to the impetus of its neighbor, but the couple above referred to is neutralized by the action of the same couple in the next carriage; while the American bogie, free of all restraints, is left to wriggle and wobble at its own sweet will.

Leaving this out of account, however, and considering that the possible angle of obliquity of the leading axle is, as above stated, the sum of two angles, of which one is directly and the other indirectly proportional to the length of wheel-base, it is clear that a truck may have too short as well as too long a wheel-base for the safe transit of a given bit of road, and that *there is a length of wheel-base which will give a less obliquity of axle than any other, shorter or longer.* The determination of this length and the calculation of the angle of obliquity for any given case is a simple matter; and it will be easy to demonstrate that there are circumstances of common occurrence under which an ordinary English carriage will traverse a sharp curve with less obliquity of axle than an American bogie.

Thus, the sine of the angle of obliquity caused by parallelism of axles is $= \frac{l}{2r}$, l being the length of wheel-base and r the radius of curve; and as the angles will in any case be small, we may say that this is approximately = the circular measure of the angle. The circular measure of the angle through which the truck can turn in either direction is approximately $= \frac{s}{l}$, s being the play of the flanges, i. e., gauge of rails minus gauge of wheels outside flanges. Thus the obliquity of axle $= \frac{l}{2r} + \frac{l}{s}$.

And the length which will give the smallest angle of obliquity is $= \sqrt{2r\,s}$

Now let us take a 10-chain curve for example; and as the gauge is sure to be widened on such a curve, and we have to take the *worst case*, it will not be too much to assume that s may be = 1 in. Then using the above formulæ, we find that the best length of wheel-base, or that which gives the least obliquity of axle in this case is about 10 ft. 6 in. (an ordinary English carriage), while *an American bogie of 5 ft. wheel-base would actually present its leading axle at as great an angle of obliquity as a carriage with 22 ft. wheel-base.* On flatter curves, supposing the play to remain the same, the disadvantage of the short wheel-base is even more apparent.

The conclusion to which we are driven, then, is that though on sharp curves a long wheel-base is dangerous, yet the difficulty is not to be obviated by shortening it, because of the unsteadiness thereby induced; and the only satisfactory solution of the problem will be by some simple arrangement by which the wheel-base may be maintained of

any desired length, and the axles truly radiated to the curve.

VELOCIPEDES.

From "Engineering."

We have for a long time excluded the subject of velocipedes, as one of diminutive carriage building, from the pages of "Engineering"; but they have in the mean time become articles of extensive manufacture by large and long established firms of mechanical engineers, railway carriage builders, and others. In Birmingham, for example, at least three eminent firms are engaged in making, by scores, if not by hundreds, what, a year or two ago, were thought to be little better worthy the attention of engineers than Bath chairs or perambulators. The principal of a velocipede—and with all their alleged differences velocipedes are much alike—is a little paradoxical to those who consider it for the first time. How is it that they can stand upright on two wheels only, one trailing behind the other? And how is it that the rider can accomplish fifty miles as easily, if not easier, than eight or ten miles of walking? As to the first question, the principle is the same as that which keeps a boy's hoop upright as long as it is kept in rotation, the tendency of all revolving bodies to continue in revolution in the same plane as that in which they were first made to revolve. With internal propelling mechanism, a velocipede might run by itself, the rider, who once puts it into motion, has only to preserve his own balance, and not that of the machine *per se*, which, once equilibrated on both sides when at rest, will take care of itself when in motion.

As to the reason why there is less fatigue in working a velocipede than in walking, a little examination is necessary. Whatever the weight of the velocipede and rider, it is a rolling weight only, and the resistance to rolling, at, say, ten miles an hour, will not much exceed one-fortieth of the weight when this is moved over a smooth, level road. Taking the total weight as 210 lbs., or, say, 15 stone, the rolling resistance would be but 5¼ lbs., and as a muscular man can easily, for an hour or more, and under the exhilarating influence of a race, work up to at least 4,620 foot-pounds per minute, this would correspond to an advance of 880 ft. per minute, or ten miles an hour. The late Mr. Glynn's work on cranes quotes instances of a much greater exertion of human strength for short intervals, in some cases nearly 30,000 foot-pounds per minute, or much above the average power exerted by an ordinary horse, and nearly equal to the standard horse power of the engineer. The writer himself, weighing 180 lbs., has often raced up a circular staircase of fifty-six steps, and rising 32 ft. 6 in., in thirteen seconds. Were this rate continued (not that he could so long continue it) for even a minute, it would correspond to the exertion of 27,000 foot-pounds in that time. One-sixth of this work, or 4,500 foot-pounds per minute might, probably, be continued for a considerable time, and this would carry him and his velocipede at nine or ten miles an hour on a good level road. The force would be exerted in the latter as in the former case by the great extensor muscles of the legs, the weight of the body being wholly carried on the velocipede, instead of being lifted as on the staircase.

In walking, muscular strength is expended in alternately lifting, by either leg, its fellow leg, and the weight of the whole body above both legs, through a distance, at each step, corresponding (were there no "spring" to the feet) to the rise of the arc described by the body in swinging over either leg upon a fixed unyielding fulcrum at the foot. The beautiful mechanism of the foot, of itself, takes off a good part of this lift, but neither the head nor any portion of the body advances in a truly horizontal line when walking, this being the case only in rolling along a level plane. There is, too, the irregularity of advance of the body, which is accelerated and retarded at each step to give time to "change legs," and there is the power expended in moving the legs themselves, considered as weights, to be stopped and started at every step. In this way, together with the strain imposed upon the muscles of the legs in the mere statical support of the body, as much fatigue may be occasioned in an hour's walk of three miles as in a spin on a velocipede at three or four times the speed.

And the bicyclical contrivances appear to possess a commercial value in their use. At any rate we hear of a firm of mechanical engineers who assert that they save 40s. weekly on an average, in cab fares, messengers, &c., by retaining a sharp velocipedestrian as a means of communicating between their two establishments, less than half a mile apart, a private telegraph being unavailable for the transmission of drawings, parcels, samples, daily accounts, &c.

TRANSMITTING POWER BY ROPES.

From "Belting Facts and Figures," by J. H. Cooper, in the "Journal of the Franklin Institute."

Among the more recent improvements in the way of *transmitting power* for long distances, is the substitution of belts by endless wire ropes, running at a high speed; their use bids fair to add immensely to our manufacturing facilities. The distance to which you can thus transfer power ranges from 75 ft. to 4 miles. Just where the belt becomes too long for economy, there the rope steps in. In place of a flat faced pulley, a narrow sheave with a deep flaring groove is used, the groove being filled out, or lined rather, with leather, oakum, india rubber, or some other soft substance, to save the rope. The essential points are a large sheave, running at a considerable velocity, and a light rope. When the distance exceeds 400 ft., a double grooved wheel is used, and a second endless rope transmits the power 400 ft. further, and so on indefinitely. The loss by friction is about 8 per cent per mile. A few examples may prove of interest, and give information.

It is required to transmit 300 horse-power by means of a wire rope. A wheel 14½ ft. diameter, making 108 revolutions per min., is sufficient; the rope running at a rate of 4,920 ft. per minute—size of rope required, one inch diameter. The distance has nothing to do with it. Again: "It is desired to transmit for any distance as much power as a 12 in. belt will give." Assuming that the belt travels in the neighborhood of 1,300 ft. per minute, it is about equivalent to 20 horse-power, and a grooved sheave of 7 ft. diameter, running 100 revolutions per min., with a ⅝ in. rope, will be the proportions required. Again, a 4 ft. wheel, running 100 revolutions per minute, with a ⅜ in. rope, will convey from 4 to 5 horse-power. The cost of the rope is always the smallest item, amounting to a few cents per foot, and not one-tenth the cost of an equivalent amount of belting. One is thus enabled, at a small expense, to transmit power in any direction; for instance, to a building lying remote from the main factory buildings, where it is not worth while to put up a separate engine. Across rivers, creeks, canals, streets, over the tops of houses, under water, from cellar to roof, etc.

Frequently an excellent site for water power remains unimproved for want of suitable building sites in the neighborhood. The water may be conveyed *down stream* by means of expensive canals and flumes; but by a wire rope transmission we can transfer it in any direction, either up stream, across it, or sidewise, up and down grades of one in eight—in fact, anywhere. "In many sections of our country coal is dear and water power plenty, but not improved, for reasons which may be set aside by the above method. In Europe over a thousand factories are driven in that way."—*The Manufacturer and Builder*, Feb. '69, p. 38.

In a paper by Mr. John Ramsbottom, in "Newton's Journal," vol. XXI, p. 46, on traversing cranes at Crewe Locomotive Works, dated January 28, 1864, mention is made of the means by which power is communicated from the shop lines of shafting to the gear of the cranes. It consists of a ⅝ in. diameter soft, white cotton cord, weighing about 1½ ounces to the foot, running at the rate of 5,000 ft. per minute, in a line with the longitudinal motion of the crane, above the same and over a 4 ft. diam. tightener sheave. This sheave is weighed so as to put a tension on each strand of the cord of 108 pounds, which is found to be the best working strain for keeping the rope steady, and giving the required "hold" on the main driving pulley. The cranes have a span of 40 ft. 7 in., a longitudinal traverse of 270 ft., and the rails are 16 ft. above the floor. The cord is supported every 12 or 14 ft. by cast iron fixed slippers of plain cross section, 1⅜ in. wide, with side flanges. These slippers are placed 1½ in. below the working line of the driving side of the cord, so as to allow the driving wheels on the traverser to pass them; they are not oiled, and the friction of the cord in them amounts to two-fifths of the working load.

Motion is communicated to the gear of the crane by pressing the cord into grooved cast iron pulleys. The grooves in the driving pulleys are V shaped, at an angle of 30°, and the cord does not touch bottom; the guide pulleys have circular grooves, same diameter as the cord, and the pressure pulleys have a circular groove of larger diameter than the cord. The driving pulleys have a diameter equal to thirty times the diameter of the rope. Guards are put on the pulleys to keep the ropes in. The driving power of the cord to lift 25 tons is only 18 pounds, irrespective of friction, which is a ratio of 3111:1. Light loads are about 800:1. In the gib cranes, driven by similar means, the ratio is 1000:1 when

lifting 4 tons at the rate of 5 ft. 1½ in. per minute. The actual power required to lift 9 tons, besides the snatch block and chain, has been found to be 17 pounds at the circumference of the driving pulley. The crab, when unloaded, requires 1½ pounds to overcome its friction. The cords are soon reduced to $\frac{9}{16}$ in. diameter, and last about eight months at constant work. In an overhead traverser, used in the boiler shop, lifting six tons, three years in use, a ⅜ in. cord was employed, but was afterwards changed for a cord ½ in. in diameter. The light driving cord is the only plan compatible with high speeds; a heavy chain, belt or cord, would soon wear out and break by its own weight.

THE CENTRAL RAIL.

From "The Engineer."

The really successful thing, and perhaps the only complete success, on the Mont Cenis Railway is the central rail. Without even stating that the central rail is absolutely required, if we merely consider the tractive force required on the Mont Cenis, it seems to us to be the most important innovation in locomotive work that has been made during the last twenty years. It is the only means yet discovered of obtaining adhesion without increasing weight, or without that adhesion being dependent on weight for its existence. Apart from the plan of applying powerful electro-magnets to the wheels, which has not been found to answer, though tried more than once; and the fixed rope scheme of Mr. David Greig—avowedly only a substitution for the central rail—the central rail constitutes the only system yet conceived for working a locomotive independently of the adhesion obtained by its weight. It is remarkable how difficult locomotive engineers, even of great ability, find it to disconnect in their minds great tractive power with the rail-adhesion produced by the actual weight of the engine bearing on the driving and coupled wheels. With ourselves it has always seemed a mechanical absurdity to provide weight in order to get the power to lift it up and carry it along. With all the wheels coupled together the maximum obtainable adhesion is obtained; but there is practically no limit to the amount to which the horizontal wheels in the Fell engine can be brought to clip the central rail. The central rail again offers a comparatively immense amount of security against running off the line, and an admirably speedy and safe means of braking the train on a descent. Certainly, when looking down the precipices passed by the Fell trains, without the knowledge of the use of the central rail we should scarcely have felt unconcerned and comfortable. The force of the wind also on these mountain passes is sometimes so tremendous that the extra protection and hold afforded by a central rail is an absolute necessity.

Working with a central rail has more than once been proposed during the last forty years; but in great improvements, not merely the man, but also the hour, must come together. Vignoles and Ericsson patented in 1830 the central rail with very different motives and views to Fell, and certainly not with the intention of getting an engine and train over such sharp curves and steep inclines as those on the Mont Cenis. An American engineer, however, not merely patented the plan in England, but actually carried it out for a short time in America, though he afterwards dropped it, proving that he had not that faith in the plan which he might have had if he had fully understood its importance.

It would not be fair to compare the central rail with schemes which have never been tried. The heavy Engerth engines on the Semmering have scarcely been a success, either in themselves or in their effects on the permanent way. What is the result of some of the very best practice in the kingdom when seeking to obtain greater adhesion from actual weight? On the Metropolitan Railway, engines weighing about forty-two tons have to be employed to draw trains weighing about eighty tons. In this there seems to be a sort of mechanical contradiction of terms. Mr. Fell's engines have been stated by Mr. Brunlees to weigh only sixteen tons, and putting twenty-four tons pressure on the horizontal wheels, plus the weight of the engine itself, the co-efficient of adhesion of one-fifth gives a total adhesion of one-half the weight of the engine. It must also be borne in mind that when people speak of getting on an ordinary line of rail an adhesion of one-fifth, or even more, of the load, they tacitly assume the rails to be in good condition. With rails in bad condition it is believed by engineers of the highest standing that whatever may be the weight of the engine, the wheels are liable to slip. There is also special reason on this line why, apart from other causes, an extra amount of adhesion is required. It appears that on the Mont Cenis a fine dust of a most lubricative

nature is blown down upon the rails in dry summer weather. This is the dust of the schistose rock of which the road—which is still partly used for ordinary traffic—is mended, and when wetted besides, the rails are sometimes in a worse condition for adhesion than from the snow in winter.

It is not perhaps impossible that such light loads as those now taken up Mont Cenis could be taken without the central rail; and certainly this might be done *if* the line were straighter—but whether with as much safety is another and a very different question. Suppose, then, we assume it as proved that the adhesion produced by weight alone would carry a remunerative load up a gradient of 1 in 10 or 12, how about passing such sharp curves as there are on the Mont Cenis? In the first place, the central rail diminishes the friction in passing round very sharp curves; and the wonder is even witnessed on the Mont Cenis that sharp curves are passed more easily than the straight line in an ordinary line, the resistance to traction on a curve of only 400 ft. radius has been estimated as *double* the resistance on a straight line on a level. And there has been no instance of an engine running off this line—no small advantage with a precipice on one side of you thousands of feet deep.

In fact, the wonder in passing the Mont Cenis is not so much at the tractive power of the engine—as the load is but slight—but the ease with which the train winds its way over a serpentine road, passing over curves of little more than five or ten chains radius. The horizontal gripping wheels of the engine, and the horizontal guide-wheels of the carriages, keep the train true on the line, and prevent much of the usual prejudicial action from coming into play. Just as the adhesion is practically unlimited, so is the brake power in descending the steep gradients. On such a difficult line as an Alpine line—whereon, in winter, guards have to be placed to warn as to descending avalanches—the ease whereby a train can be stopped is of the greatest necessity. We think that very few disinterested people can come to any other conclusion than that, on such lines, with such complicated conditions, differing so much from our own, the central rail system is the only one to be depended upon for tractive and brake power, flexibility round the curves, safety to life, and practicable cheapness. It seems to us not impossible that we should have an approach to perfection in a sort of combination of the engines advocated by M. Thouvenot and Mr. Fairlie with the central rail. Of these two tank-engines, placed back to back—united as to their fire-boxes and boilers—one pair of cylinders could work the four coupled wheels of one bogie-frame in the ordinary way, and the other pair could be set to work the gripping wheels on Fell's plan on the second frame. With such a combination there need scarcely be a single piece of gear more than if only vertical driving wheels were used.

GOODS ENGINES FOR STEEP INCLINES. —The Paris, Lyons and Mediterranean Railway Company will work the steep inclines of the new branches now in progress with eight coupled engines of a new pattern. Twelve engines of this system are being manufactured at the Graffenstaden Works, at the price of £52 8s. 3d. per ton, but the working drawings were prepared in the offices and by the engineers of the company. These engines have fire boxes overhanging the rear drivers, and outside cylinders. The valve gear is also outside, the eccentrics being supported by an overhang to the end of the crank pin of the driving axle. The frames are curved transversely to clear the fire box, which is of unusual width. The curved part of the frame is strengthened by a strong wrought iron bracket, a contrivance which has been used with much success by the Eastern Railway. The first and fourth axle have an end play of 1 in. in the brasses, and spherical crank pins for the coupling rods, enabling the engines to pass easily round curves 720 ft. radius; all the wheels are, of course, flanged. The engine is suspended by eight springs and four compensating beams. The boiler is fed by a single injector, connected through two india rubber pipes to a tender, which has nothing worth noticing, and weighs about twenty tons in working order. The engines, as well as all the other engines of the company, are fitted with the Lechatelier reversing arrangement, and Thierry's smoke-consuming apparatus. The following dimensions of the most important parts of these engines are from "The Engineer."

Fire grate.

	ft.	in.
Length	5	1
Width.	4	5⅛
Surface in square feet	12⅓	

	ft.	in.
Inside fire box.		
Height next the tube plate	5	10 1/5
Height next the door	5	4 2/5
Inside width at the top	4	2 4/5
Inside width at the bottom	4	5 1/5
Inside length at the top	4	6 4/5
Inside length at the bottom	5	1
Thickness of fire box, copper.		
Door plate		2/5
Side plate		2/5
Top of tube plate		1
Bottom of tube plate		3/5
Tubes.		
Number	244	
Outside diameter		2
Length	17	7
Heating surface of fire box (sq. feet)	106	
Heating surface of tubes in sq. feet	2,132	
Total heating surface in sq. ft.,	2,238	
Outside fire box.		
Length at the top	5	3 4/5
Length at the bottom	5	7 4/5
Width	5	0 3/5
Thickness		16/25
Boiler.		
Diam. outside of smallest plate	4	11
Length	17	3
Thickness		16/25
Height of the center above the rail	6	6 2/5
Steam pressure	125 lbs.	
Diameter of each safety valve		5 1/5
Chimney.		
Diameter	1	9
Height above the rail	14	4
Frames.		
Inside distance at the front	3	11 3/5
Inside distance at the back	5	10 1/5
Thickness		1 1/5
Total length of the engine	32	2
Wheels.		
Diameter	4	1 3/5
Distance of axles	4	5 1/5
Total wheel base	13	3 2/5
Miscellaneous.		
3d axle		8
1st, 2d and 4th		7 1/6
Length of journals		10
Diameter of cylinders	1	9 1/5
Stroke	2	2
Length of connecting rods	8	4 2/3
Distance between centers of the cylinders	6	13 2/5
Angle of advance of eccentrics,	35 deg.	

	ft.	in.
Throw of eccentrics		2 4/5
Stroke of slide valve in full gear		5 3/5
Inside lap of slide valves		1/32
Outside lap of slide valve		1 1/6
Average admission in full gear		4/5
Length of steam and exhaust ports	1	2 1/5
Width of steam ports		1 4/5
Width of exhaust ports		3 3/5
Number of spring plates	11	0
Width		3 3/5
Thickness		1/2
Length	2	10
Camber		3 1/5
Distance of center of gravity in front of 3d axle	2	0 2/3
Total weight of engine empty	43 tons.	

Distribution of weight in working order.

	tons.	cwt.
1st axle	12	0
2d axle	12	0
3d axle	12	13
4th axle	12	13
Total weight	49	6

These engines are especially designed for working steep inclines at very small speed. A single engine will easily take, at ten miles an hour, a 200-ton train up an incline of 1 in 40, or better, two engines, one at the front and the other behind, will work a 400-ton train. With so small a speed the overhang of the fire box and the end play of the leading and trailing axle are without any practical inconvenience. The company do not intend, of course, to work their main lines with these engines, where the speed is much greater, and where the six-coupled engines now in use are quite sufficient.

BRITISH HEAVY GUNS.—In a recent article, the London "Times" drew attention to the comparative trials for endurance of 9-in. guns now in progress at Woolwich. It was stated that one pattern of the Woolwich coiled wrought-iron gun had endured 400 rounds with ordinary service charges of 30 lb. English large-grain cannon powder, and 714 rounds with battering charges of 43 lb.; in all, 1114 rounds—a test far beyond anything that such a gun could probably be called upon to resist even during a great war. The gun remains perfectly serviceable. The gun and its ammunition were calculated for each other, regard being had both to power,

endurance, weight, and cost; and that there may be no mistake as to the powers of the Woolwich 9-in. gun, with battering charges of 43 lb., we give the maximum penetrations which the gun is capable of effecting, as laid down by the Committee on Fortifications: into earth 40 ft., into concrete 12 ft., into brickwork 12 ft., into rubble masonry 8 ft., into massive granite 2 ft. (but with fracturing and disintegrating effect to a much greater depth, and over a considerable area), into iron plating 11 in. Well-trained gun detachments can, if the circumstances are not unfavorable, load, aim, and fire the 9-in. gun at the rate of one round per minute, so that a six-gun battery could deliver a shot or shell well aimed every 10 seconds.

The difference between the second or ordinary pattern of the Woolwich gun and its predecessor under trial consists in certain details of construction. The first trial gun had a steel tube only 2 in. thick, the second a 3-in. tube. In the first the coils intended to form the breech of the gun were made up in two masses, so that the breech consisted of two layers of wrought iron over a thin steel tube. In the second the whole of the wrought iron covering the breech of the tube had been previously welded up into one mass, so that the breech consisted of one layer of welded coils over a thick steel tube. The result has been in favor of the gun with less steel and more iron disposed in two layers. The endurance of both pieces has been eminently satisfactory.

The second gun has fired 400 rounds with 30 lb. charges, and 649 with 43 lb. charges—1,049 rounds in all. During the firing of the 400 charges of 30 lbs. and during 207 of the 43 lb. charges, the vent was in rear of the usual place. The last 442 rounds with 43 lb. were fired through a vent in the ordinary service position, which is more severe upon the gun. The piece is now unserviceable, but became so by a most gradual and easily watched process. About 200 rounds before the end of the trial a flaw was detected in the steel tube. It developed gradually, though the steel barrel is tightly gripped by the wrought-iron exterior, up to the 1002nd round, when gas was discovered escaping from the indicator hole—a small orifice bored in all our heavy guns to give notice when a steel tube is cracked through. The proof was continued with full battering charges until, at the 1049th round, the steel tube shifted forward about 2 in. and closed the vent, so that further firing became impossible. Thus, though the gun is unserviceable, it has stood an enormous test, and yielded slowly at last, step by step. We need hardly say that no accident could possibly have happened to any one. Cases, very few and far between, might possibly occur of a Woolwich gun bursting at proof if the steel tube happens to be exceptionally bad, because the proof charge is inordinately large. We have known one such case. Indeed, the proof is intended to test thoroughly every part of a gun, not merely the interior. This trial was merely comparative; but, while it has shown the advantage of using thin interior steel tubes or barrels in preference to thicker ones, it has also shown that Woolwich guns, made on either pattern, are capable of an endurance entirely unknown among the expensive heavy guns possessed in extremely limited numbers by Continental powers.

TESTING STEAM ENGINES.

From "Engineering."

Although the ordinary method of expressing the performance of a steam engine by stating the number of pounds of coal per horse power per hour consumed in working it, no doubt possesses some points of practical convenience, yet as a means of comparing accurately the performances of different engines it is absolutely valueless. That this is the case will be readily admitted when it is considered that the number of pounds of coal consumed per horse power per hour by any given engine may be varied within very wide limits without the engine itself being modified in any way. Any given engine working at a given speed, under a constant load, and supplied with steam at a constant pressure, will, so long as no derangement of its parts takes place, consume a certain constant quantity of that steam per hour; but, on the other hand, the amount of fuel consumed in generating this quantity of steam may vary considerably according to the description and proportions of the boilers used, the quality of the coal burnt, the care and skill exercised in stoking, the means adopted to prevent loss of heat by radiation, and other details which it is unnecessary that we should mention here. It thus follows that a bad engine supplied with steam by an economical boiler worked by skillful stokers may, according to the ordinary method of estimating performance, show as good a result as an engine which is

in reality very superior to it, but which draws its supply of steam from boilers of less efficient proportions, or less carefully fired than those of its rival, and this although the same quality of coal is used in the two instances. Even if the two engines are supplied with steam from boilers of the same class fired with equal care, the comparison is rarely a perfectly just one; for with all boilers there is a certain rate of evaporation at which the consumption of fuel per pound of water evaporated is less than at any other, and it may—and in practice probably always will—happen that the supply of steam needed by the one engine will approach more nearly to this rate of most economical evaporation than that required by the other, and hence an inequality of which it is impossible to estimate the amount with accuracy. The fault, in fact, of the ordinary system of estimating steam engine performance is that it considers the engine and boiler as a whole instead of regarding them as two entirely independent parts, either of which may be good or bad without in any way affecting the efficiency of the other.

A better measure of the efficiency of any given engine than the number of pounds of coal consumed per horse power per hour in supplying it with steam, is the weight of that steam as estimated from the quantity of water evaporated by the boiler. We say *estimated* advisedly, for there are but few boilers which do not prime to some greater or less extent, and the amount of this priming will, of course, always cause the apparent evaporation to be somewhat greater than that which actually takes place. The practice of estimating the efficiency of an engine by the quantity of water consumed by it, has, however, never become a general one, and there are abundant reasons why this should be the case. To ascertain accurately the quantity of water consumed per horse power developed by any given engine is practically no very easy matter. In the first place the power exerted by the engine during the trial must be constant—or so nearly constant that the mean power exerted may be accurately estimated—and this is a condition which, except in the case of engines employed for pumping water and a few other instances, is very difficult of attainment for any lengthened period of time. Next, the quantity of water supplied to the boilers must be accurately ascertained, not by water-meters, which are rarely thoroughly accurate, but if possible by direct measurement in a tank or equivalent contrivance, allowance being made for variations of temperature; thirdly, care must be taken that no steam is taken from the the boiler for other purposes than supplying the engine, and that there is no leakage from valves, cocks, etc.; and fourthly, the water level in the boilers should be the same at the termination of the experiment as at its commencement. In the case of marine engines also with boilers worked with salt water, of which a certain proportion has to be blown off at intervals, the amount thus blown off would have to be ascertained. Altogether such experiments require not only careful, but skilled superintendence; and as, to be of practical use, they must be of lengthened duration in order that inaccuracies due to variation of water level, etc., may be as much as possible eliminated, they are necessarily expensive to carry out, and are consequently seldom resorted to.

Having stated the errors and inconveniences incidental to the ordinary methods of comparing the performances of steam engines, it is only fair that we should point out a method of making such comparisons to which the above mentioned objections do not apply. This method is a very simple one, and consists merely in measuring the heat carried off from the engine by the exhaust steam, this steam, this heat being, in the case of a condensing engine, of course imparted to the water used for effecting condensation. It has long been a practice with many engine-drivers to roughly estimate the temperature of the water in the hot wells of their engines, by dipping their hands in it, and in this way to get some rude idea of the manner in which their engines are working; and several engineers, and amongst them Mr. David Thomson, have by supplying an engine with a constant amount of condensing water, and noticing the variations in the temperature of the latter estimated the relative economy of different rates of expansion etc, when working against a given load. The merit, however, of reducing this method of testing engines to a system, and devising means for carrying it out in a simple yet thoroughly accurate manner is due to Mr. B. W. Farey and Mr. Bryan Donkin, jun., of the firm of Messrs. Bryan Donkin and Co., of Bermondsey, who have during the past eighteen months or so ascertained the performances of a number of engines in this way both in this country and abroad. In a letter addressed to us, and which was published in Engineering of the 17th of July

last, (*vide* page 58 of our last volume), Mr. Farey drew attention to this mode of testing engines, and gave a description of the apparatus employed; but it may nevertheless be convenient that we should give some particulars of the system here.

The principles upon which the system is founded may be very simply stated. A steam engine is but a form of heat engine, receiving its supply of heat from the boiler, and converting a greater or lesser portion of this heat into useful work. The more efficient the engine the greater will be the proportionate amount of heat thus transformed into work, and the less consequently will be the proportionate quantity carried off by the exhaust steam. We thus see that we measure the quantity of heat carried off by the waste steam of any engine during, say, a minute, and divide this quantity by the number of horse power developed by the engine during that minute, we get a certain number or constant which will enable the performance of that engine to be compared accurately with that of any other engine tested in a similar way. The more efficient the engine the lower, of course, its "constant" will be, and *vice versâ*.

We must next consider the means by which the quantity of heat carried off by the exhaust steam can be measured, and we may here remark that nothing could be more simple, and at the same time more accurate, than the apparatus which Messrs. Farey and B. Donkin, junior, have devised and employed for this purpose. In its simplest and most generally useful form, it consists merely of a wooden trough, or box, into which the whole of the water from the hot-well is led, this trough having several partitions across it, over and under which the water flows, so as to obtain at last a steady current, which, at one end of the trough, falls over a weir or a "tumbling bay." The height or head of water above the weir can be readily determined by the ordinary hook gauge, and this and the breadth of the weir being known, the quantity of water discharged in a given time can be readily and accurately calculated by the use of Beardmore's Tables, or equivalent formulæ. In practice it would be unnecessary to make these calculations more than once for any given apparatus, it being, of course, more convenient to mark on the gauge the discharge per minute corresponding to each given amount of head. To ascertain the temperature at which the condensing water enters the condenser and finally escapes, a good thermometer is, of course, all that is required. The number of degrees that the water is raised in temperature during its passage through the condenser, and the number of pounds of water thus heated during a given time, being known, we can, by merely multiplying these two quantities together, determine the number of pound-degrees of heat or thermal units carried off from the engine during that time by the exhaust steam. Dividing this number of pound-degrees by the number of horse power developed by the engine during the trial, we get the "constant" already mentioned.

All, then, that is necessary to test an engine on Messrs. Farey and Donkin's system is a wooden box with a tumbling bay, a good thermometer, and indicators for determining the power developed. It is by no means necessary that the trial should be a lengthened one, for it will be found that as long as a constant pressure of steam is maintained, and the engine is employed to do an uniform amount of work, the amount of heat carried off by the condensing water will also remain constant from hour to hour, and there is, therefore, no reason why the experiment should be extended for an inconvenient time. This is a very important point in favor of the system of testing of which we are speaking, as in all mills or factories an engine can be kept doing tolerably uniform work for a couple of hours or so without inconvenience, whereas if the trial had to be extended over a lengthened period (as would be essential if the quantity of water evaporated by the boilers and the amount of coal consumed were obtained in the ordinary way) much inconvenience and expense would be in most cases incurred.

We must now speak of another important point connected with this system of testing engines. Mr. Farey and Mr. B. Donkin, junior, have found, from experiments, that the "constant" of any given engine does not vary to any practical extent with moderate variations of power; and thus when the "constant" has once been obtained, the power developed at any given time by an engine fitted with the apparatus we have described can be ascertained very closely without the use of the indicator. For instance, let us suppose that it has been ascertained that the "constant" of any given engine is 480 or, in other words, that the exhaust steam of that engine carries off 480 pound-degrees of

heat per minute for every indicated horse power. Then if, on observing the apparatus, it was found that 14,400 units of heat were passing away per minute, the engine would then be developing $\frac{14400}{480} = 30$ horse power, or if 16,800 units were being given off per minute, $\frac{16800}{480} = 35$ horse power would be developed, and so on. We thus see that the apparatus affords a very ready means of estimating the power requisite to drive various machines, shafting, etc., and we are inclined to believe that if it was generally applied to these purposes some curious revelations would be the result.

In cases where it is desired to maintain a continuous registration of the work done by an engine, Messrs. Farey and Donkin employ the simple arrangement of photographic apparatus described and illustrated in the letter from Mr. Farey to which we have already referred. According to this plan, two rays of light from a gas burner—the one passing through a hole in a screen carried by a float, and the other through a break in the mercurial column of a thermometer—are, after traversing lenses, made to fall upon a sheet of sensitized paper carried by a slowly revolving drum, which derives its motion from the engine. Each ray of course traces a line upon the sensitized paper, and by the distance of these lines above or below a fixed datum line traced by a third ray of light, the quantity and temperature of the water passing over the weir at any given time are registered. Applied in this way, the apparatus is calculated to do good service to large millowners and waterworks companies who desire to obtain a continuous record of the performances of their engines.

Hitherto we have spoken of this system of testing as applied to stationary condensing engines only; but it is also applicable to high-pressure engines, and, under certain circumstances, to marine engines. In the case of high-pressure engines, the exhaust steam would have to be turned into a tank of water and condensed, and the water thus heated could then be treated like that from the hot well of a condensing engine. In the case of marine engines, the vessel containing the engines to be tested would have to be lashed alongside a wharf, and the engines being got up to their intended working speed, the water from the hot well would have to be conducted into a box fixed to the wharf, and measured in the way already described. Of course in actual trials at sea some other method of measuring the water discharged from the hot well would have to be devised; but this being done, the system of testing would be as applicable at sea as on shore, as the rise of temperature of the condensing water could of course be readily ascertained.

We have spoken, at some length, of the system of comparing the performances of steam engines proposed by Mr. B. W. Farey and Mr. B. Donkin, jun., because we are convinced that it is one deserving the most attentive consideration of all employers of steam power. The experiments required for its application to any engine are of the most simple and inexpensive kind, and, when once understood, they may be carried out as easily as the taking of an ordinary indicator diagram. The system, moreover, gives for each engine a "constant," the favorableness or unfavorableness of which is entirely dependent on the performance of the engine itself, and which is not affected in any way by the efficiency or inefficiency of the boilers, by the quality of the coal used, or by the greater or less skill of the stoker. Once let such a standard of comparison as this become generally adopted, and we shall hear less of vague performances and more of really economical steam engine—a state of affairs earnestly to be desired.

LOADS ON GIRDERS.—At a recent meeting of the Société des Ingénieurs Civils M. Leygue presented to the Société a detailed study on uniformly distributed loads, which, in their results, are equivalent to the loads caused by traffic on metal superstructures; that is to say, capable of producing in the sections submitted to the greatest strains caused by separate loads, the same maxima momenta of flexion.

M. Leygue first examined the conditions of variation, to the extent of the movement of the loads, of the maxima momenta produced by a series of forces, P, acting on a body resting freely on two level supports. In discussing the expression

$$\mu = A + B\,z,$$

which is the usual formula of flexion momenta for any section, he found that in the position, z, the most unfavorable of the system, one of the loads, P, was to be found in the section undergoing the greatest strain.

From this point the question of uniformly

distributed loads becomes remarkably simplified.

If x be the abscissa of the maximum momentum under any specified load; π the uniformly distributed load producing the same effect as the separate loads, P; L the bearing of the girder; p the uniformly distributed load caused by the dead weight; F the resultant of distinct forces, P'; λ the distance of the load under consideration to the resultant, F; Σ P l the sum of the momenta in relation to the load under consideration, of the separate loads placed at certain distances on the abscissa x, we find

$$x = \frac{L}{2} - \lambda \frac{F}{2F + pL}$$

and

$$\pi = \frac{2F}{L}\left(1 - \frac{\lambda}{L - x}\right) - \frac{2 \Sigma P l}{(L - x)\, x}.$$

After having examined the conclusions to be deducted from these formulæ, M. Leygue presented to the Société the results of their application to underline and overline roadways. The calculations are arranged in the shape of tables and curves, in which the values π are considered as representing the performance of the bearings of the girders.

The general shape of the curves thus traced is hyperbolical with two rectangular asymptotes:

$$x = o \text{ and } y = \text{constant}.$$

In face of such results, and foreseeing what must take place in other companies from what has taken place in the Compagnie du Nord, M. Leygue was surprised that straight lines of 400 K., 4,000 K., and 5,000 K., should still be the standard indications in the administrative orders of the controller's office. It would seem to be more reasonable to permit the engineers to fix upon the loads for which they must calculate their works, and to simply place a certain limit to the molecular strains to which the metals may be submitted. In fact, the different pitches would allow the degree of stability of the works to be ascertained.

M. Leygue believed that the figures obtained by the formula (π) were also applicable to continuous girders supported by several bays. In fact, in a case of entire symmetry there will be found for a piece built in horizontally at both its extremities,

$$\pi = \frac{N\,(N + 2)}{N + 1} \cdot \frac{P}{L},$$

N representing the number of separate loads, P, distributed on the bay L; and this formula will be found *identical* in the hypothesis of free supports.

M. Leygue concluded by saying that he agreed with the expressed opinion of M. Bresse that the motion of the loads ought not to have a disturbing influence on the works. If certain observations seem to contradict this opinion, the reason probably is that the girders, by the relation of their component parts, were placed beyond the typical limits as regards which theory and practice are not in contradiction to each other. For this reason M. Leygue supported without any alteration the figures obtained by him, deduction being made for the speed of the rolling loads.

THE IRON AND STEEL INSTITUTE OF GREAT BRITAIN.—This body comprises upwards of 140 of the leading iron and steel masters, managers and engineers of the kingdom. Its objects as defined in the printed rules are, 1st, to afford the means of communication between members of the iron and steel trades upon matters bearing upon the respective manufactures, excluding all questions connected with wages and trade regulations; 2d, to arrange periodical meetings for the purpose of discussing practical and scientific subjects bearing upon the manufacture and working of iron and steel. The several similar institutions devoted more especially to civil engineering have proved of such signal advantage to all concerned, that great hopes are entertained of the usefulness of this new enterprise.

GOLD REGION IN SOUTH AFRICA.—"Peterman's Mittheilungen" contains a report on the gold region discovered by K. Mausch, in the south of Africa, between Limpopo and Zambesi. Quartz rock, very rich in gold, is found there extending over a length of many miles. Gold sand rich enough to be washed to advantage has not yet been discovered. Captain Black, who has acquired a considerable experience in gold mining in California, is managing the mining operations. He wishes to annex this gold district to the Cape Colony, and has given it the name of Victoria district. Gold mining companies have been organized in Natal, in the Transvaal Republic, and in the Cape Colony. Several European geologists have started for Africa. A scientific man is being sent there from England. Already, in October last, Germany sent Mr. Ed. Mohr, the experienced traveller, well acquainted with the south of Africa, and accompanied by O. Hübener, of the Frei-

berg Mining Academy. They have gone to Natal and the Transvaal Republic with the purpose of subjecting the gold district mentioned to a closer investigation.—*Oestr. Zeitschrift.*

NEW METHOD OF RIFLING AND WORKING HEAVY GUNS.—The "Mechanics' Magazine" for May 14, 1869, illustrates in detail the scheme referred to, as designed by Mr. C. Pemberton, of the Royal Navy. A rifled bar of say 6 in. diameter is screwed into the bottom of the chamber and occupies the position in the bore that a piston-rod would occupy in a cylinder. The projectile is bored out and grooved to fit over this rifled bar, while the exterior of the projectile and the bore of the gun are smooth. The object is to avoid the weakening of the gun by the loss of metal and the sharp angles of grooves in the bore, and by the bursting strain caused by the rotation of the projectile. It appears to us, however, that the rifled bar would sag at the muzzle to such an extent as to make loading difficult.

Mr. Pemberton also shows a novel arrangement of air cylinder for taking up the recoil, and also for running out the gun; also a method of elevating the gun platform by screws, which we think vastly inferior to hydraulic power.

BLAST FURNACE ECONOMY.

From "Engineering."

To those who desire to effect economy in the carrying out of any process or manufacturing operation there is no knowledge more valuable than a knowledge of all existing sources of waste. In some cases such knowledge is easy to obtain; but in the majority of instances it is more or less difficult, and in none more so than in those in which the matter to be economized is fuel. Let us take the steam engine for example. We know that a certain quantity of fuel if properly consumed will produce a certain number of units of heat, and that if this number is multiplied by 772 we get the number of foot-pounds of work which this heat is capable of developing if completely utilised. But we also know that even with the best boilers and engines now constructed the amount of work actually developed falls immensely short of this theoretical quantity; there are losses caused by imperfect combustion, by heat carried off from the boiler furnaces, by the waste gases, by radiation, by condensation, by wire-drawing, by leakage, and by numbers of other defects, which it is unnecessary to mention here. The losses due to some of these various causes are known with tolerable accuracy, but with regard to others there is little definite information available, and the consequence is that they are not guarded against as they should be. If we knew exactly how every unit of heat developed in a boiler furnace is expended, who can doubt but that some substantial improvement in construction would be the result.

As with steam engines so with blast furnaces, respecting which we intend more especially to speak on the present occasion. That much has been done during the past few years—and particularly in the Cleveland district—to reduce the consumption of fuel in blast furnaces per ton of iron produced is undeniable; but it is equally undeniable that there is still margin for improvement, and it appears to us that one of the first steps to be made towards effecting that improvement is to ascertain with the greatest practicable exactness the losses amounting from each existing source of waste. These losses once known, they may be considered separately, and means taken to avoid them.

At the meeting of the Institution of Mechanical Engineers, held on the 28th of January last, during the discussion which took place on Mr. Cochrane's paper on the utilisation of waste gases from blast furnaces,* attention was especially directed to the differences which exist between the quantities of fuel actually consumed in blast furnaces per ton of iron produced, and the amounts which would be theoretically required; and the subject is altogether one of such importance as to deserve especial consideration. And here we may remark that it is quite impossible in the present state of our metallurgical knowledge to say precisely how much fuel is absolutely wasted in any given blast furnace. The quantities of fuel, ore, and fluxes introduced in any given time, and their analyses, may be accurately known to us; but our information concerning the quantities of heat rendered latent in destroying certain chemical combinations, the heat absorbed is liquefying the slag and iron itself; the specific heat of the liquid slag and iron, and other matters, is far from being so reliable as we could wish, and, consequently, as we have said, a thoroughly accurate estimate of the fuel required in any

* See Van Nostrand's Magazine, No. 2, p. 140.

given instance cannot, at present, be given. Notwithstanding this, however, we have sufficient data at our disposal to show that the amount of fuel actually used is greater than it should be, and it may be interesting if we consider this matter more closely. For this purpose it will be convenient if we take, as an example, a furnace worked with certain definite charges of ore and fuel, and show how the proportions between those charges agree with those which would be theoretically required.

Let us, for instance, consider a furnace, in which the charges consist of 26 cwt. of coke, 50 cwt. of ironstone, and 10 cwt. of limestone, per ton of iron run; the ironstone containing 40 per cent. of iron in the state of peroxide. We have chosen these proportions because they will enable us to readily compare our calculations with those of Mr. I. Lowthian Bell and Mr. Siemens given in the course of the discussion to which we have already referred; and which were founded on similar data. In the first place the coke used in the Cleveland district contains from 5 to 10 per cent. of ash and moisture, and if we assume that our particular sample contains $7\frac{1}{2}$ per cent. of these matters, we shall have to make a deduction of $1\frac{1}{2}$ cwt. from the quantity available as fuel. A further deduction of about 1 cwt. will have to be made for the carbon which combines with the iron, leaving finally $23\frac{1}{2}$ cwt. of carbon to be accounted for.

Peroxide of iron ($Fe_2 O_3$) consists of 56 parts by weight of iron combined with 24 of oxygen, and the 50 cwt. of ironstone charged per ton of iron made contain, therefore, 20 cwt. of iron, 8.57 cwt. of oxygen, and 21.43 cwt. of other materials, principally silica. The decomposition of the peroxide is effected by its oxygen being taken up by the carbonic oxide gas produced by the imperfect combustion of the coke, this carbonic oxide being thus converted into carbonic acid. The amount of carbonic oxide required to decompose the given quantity of peroxide of iron is readily calculated. Carbonic oxide consisting of 6 parts by weight of carbon combined with 8 parts of oxygen, and carbonic acid consisting of 6 parts of carbon and 16 of oxygen, it follows that to take up the 8.57 cwt. of oxygen from the peroxide of iron 15 cwt. of carbonic oxide (composed of 6.43 cwts. of carbon and 8.57 cwt. of oxygen) will be necessary. This disposes of 6.43 cwt. out of the $23\frac{1}{2}$ cwt. of carbon. But in converting the oxygen of the peroxide from the solid to the gaseous form there is a great absorption of heat, and to supply this heat a consumption of fuel has to take place. It appears from the researches of Ebelmen and Schinz that the quantity of heat rendered latent during the decomposition of the peroxide of iron amounts to 718 units for each pound of oxide decomposed, and as in our example the quantity of peroxide is 28.57 cwt., the heat absorbed would be $28.57 \times 112 \times 718 = 229{,}748{,}512$ units. We must next consider the quantity of fuel required to supply this amount of heat.

If the whole of the carbon consumed in a blast furnace was converted into carbonic acid, each pound of it would develop about 14,000 units of heat; but, as a fact, it appears probable that, as estimated by Mr. Siemens, not more than one-fifth is thus converted, the remaining four-fifths assuming the form of carbonic oxide. As carbon, when burnt into carbonic oxide, only produces about 4,000 units of heat, we thus have as the average quantity of heat produced by each pound of carbon consumed in the furnace $(\frac{1}{5} \times 14{,}000) + (\frac{4}{5} \times 4{,}000) = 6{,}000$ units; and this we believe is a fair estimate. From these data we get $\frac{229{,}748{,}512}{6{,}000 \times 112} = 3.418$, or, say, 3.42 cwt. as the quantity of fuel required to supply the heat rendered latent during the decomposition of the peroxide of iron. We have next to consider the amount of heat rendered latent during the decomposition of the limestone; and, according to the experiments of Schinz, this amounts to 355 units for each pound of carbonate of lime decomposed. In our case, therefore, the quantity will be $10 \times 112 \times 355 = 397{,}600$ units corresponding to the consumption of $\frac{397{,}600}{6{,}000 \times 112} = 0.591$, or, say, 0.6 cwt. of fuel.

At the time that the iron and slag are discharged from a blast furnace they have a temperature which may be fairly assumed as about 2,400° higher than that of the materials at the time of charging; and we have now to consider the amount of heat necessary to liquefy them and give them this high temperature. The amount of heat rendered latent during the liquefaction of a pound of cast iron has been given by Clement as 233 units, and by Schinz as varying in different samples from 250 to 315 units. If we assume 250 units as the amount in the present case, we shall have $250 \times 20 \times 112 = 560{,}000$ units as the amount rendered latent

during the liquefaction of the ton of iron. Again, the specific heat of cast iron in the solid state is 0.13, and in the liquid state about 0.16; and we shall, therefore, have $20 \times 112 \times 0.13 \times 2,000 = 582,400$ units of heat absorbed in raising the ton of iron to the melting point, and $20 \times 112 \times 0.16 \times 400 = 143,360$ units imparted to it after it is melted. Adding these quantities together, we get $560,000 + 582,400 + 143,360 = 1,285,760$ units; thus corresponding to the consumption of $\frac{1,285,760}{6,000 \times 112} = 1.91$ cwt. of fuel.

As to the quantity of heat rendered latent during the liquefaction of the slag, some little uncertainty exists, and it, moreover, no doubt varies in slags of different compositions. The researches of various continental experimenters, however, tend to show that 110 units per pound of slag melted may be taken as a fair estimate in ordinary cases. With the charges mentioned in our example, the quantity of slag produced would be about 29½ or 30 cwt. per ton of iron made, and taking the latter quantity, we shall have $30 \times 112 \times 110 = 369,600$ units. The specific heat of slag, like that of iron, varies according to whether the material is in the solid or liquid form; but we may, without any serious error, assume it as being 0.2 throughout. The quantity of heat required to raise the temperature of the materials forming the slag about 2,400°, will thus be $2,400 \times 30 \times 112 \times 0.2 = 1,612,800$ units; and adding to this the 369,600 units absorbed during liquefaction, we get 1,982,400 units as to the total heat imparted to the slag, this corresponding to the consumption of $\frac{1,982,400}{6,000 \times 112} = 2.94$, or, say, 3 cwt. of fuel.

Summarizing the results above obtained, we get the following statement of the manner in which the 26 cwt. of fuel is disposed of:

	cwt.
Ashes and moisture in fuel	1.5
Carbonization of the melted iron	1.0
Carbon for combining with oxygen in ore	6.43
Fuel for melting iron	1.91
" " slag	3.0
" to supply heat rendered latent during decomposition of ironstone	3.42
" ditto during decomposition of linestone,	0.6
	17.86
Not accounted for above	8.14
Total	26.0

In the above summary we have taken no account of the heat carried off by the waste gases escaping at the mouth of the furnace, for we quite agree with Mr. Siemens in considering that this amount is more than balanced by the heat introduced into the furnace by the hot blast, supposing the latter to be heated to, say, 1,000°. A simple calculation will prove this. We have shown that of the 26 cwt. of coke, 23½ cwt. would be actually consumed as fuel (for the amount which unites with the oxygen of the ore is really consumed), and of this quantity we have assumed one-fifth or 4.7 cwt. to be converted into carbonic acid, and the remainder, or 18.8 cwt., into carbonic oxide. The 4.7 cwt. converted into carbonic acid, would require $\frac{4.7 \times 16}{6} = 12.63$ cwt. of oxygen for their conversion, whilst the remaining 18.8 cwt. would combine with $\frac{18.8 \times 8}{6} = 25.06$ cwt. of oxygen in forming carbonic oxide. The total quantity of oxygen required for chemical combination alone would thus be $12.63 + 25.06 = 37.69$ cwt., and of this quantity 8.57 cwt. would be supplied by the iron ore, leaving 29.12, or, say, 29 cwt. to be provided by the blast. Taking the air as being composed of 22 per cent., by weight, of oxygen, 77 per cent. of nitrogen, and 1 per cent. of moisture, carbonic acid, &c., we have $\frac{29 \times 100}{22} = 131.7$, or, say, 132 cwt. of blast as the amount necessary to furnish the above supply of oxygen. The specific heat of air being 0.238, this quantity of blast if heated 1,000°, above the ordinary atmospheric temperature, will thus introduce into the furnace $1,000 \times 0.238 \times 132 \times 112 = 3,518,592$ units of heat.

On the other hand, the gases escaping from the mouth of the furnace consist of 4.4 cwt. of carbonic acid derived from the limestone, 8.57 cwt. of oxygen from the peroxide of iron, 132 cwt. of oxygen, nitrogen, &c., from the blast, and 23.5 cwt. of carbon, combined with the oxygen of the air and that from the peroxide of iron, in the form of carbonic acid and carbonic oxide. The total weight of the gases will thus be $4.4 + 8.57 + 132 + 22.5 = 168.47$, or, say, 168½ cwt. Taking the specific heat of these mixed gases to be 0.24, and their temperature to be 600°, we shall thus have $169.5 \times 112 \times 0.24 \times 600 = 2,717,568$ units of heat carried off by them, this quantity being $3,518,592 - 2,717,568 = 801,024$ units less than is introduced by the blast. To some extent this

over-plus would no doubt be reduced by the heat carried off by radiation from the pipes by the water circulating through the tuyeres, &c., but we think there can be little doubt that the heat introduced by the hot blast will fully compensate for that carried off by the waste gases.

It may be interesting if we compare our calculations as to the disposal of the fuel above given with the estimates given by Mr. I. Lowthian Bell and Mr. Siemens on the occasion of the discussion to which we have already referred. Mr. Bell's estimate was as follows:

	cwt.
Carbonization of the melted iron	1.0
Melting the iron, and keeping it melted on the hearth.....	2.7
Ditto as regards the cinder	4.5
Heat carried off by the escaping gases	6.36
Heat rendered latent, including the 6.43 cwt. of carbon combining with the oxygen in the ore, say, altogether	9.00
Total.....	23.56

It will be noticed that in the above estimate, although Mr. Bell allows 6.36 cwt. as the equivalent of fuel carried off by the waste gases, he makes no allowance for the heat introduced by the blast. Assuming, as we have done, that these two quantities balance each other, and deducting from Mr. Bell's estimate the 6.36 cwt. just mentioned, we get, as a remainder, 17.2 cwt., a quantity closely agreeing with that shown by our own calculations. Mr. Siemens' estimate, which also agrees closely with our own, was as follows:

	cwt.	
Melting the iron.....	1.60	
Melting the cinder.....	4.13	
Heat rendered latent by reduction of ore,	3.19	
Carbon for combining with oxygen in ore and for carbonizing pig metal...	7.43	
		16.35
Ashes and water in coke, 10 per cent.....		1.63
Calcining the limestone, &c., 10 per cent...		1.63
Total quantity of coke required.....		19.61

Of the 8.14 cwt. of coke per ton of iron, given in our own estimate as unaccounted for by the useful work done, a portion is no doubt expended in supplying the heat lost by radiation from the furnace, but we have no reliable data which will enable us to estimate what the amount of this loss will be. There is, however, little cause for supposing that it is sufficient to account for the heat generated by the combustion of about one-third of the total quantity of fuel, and there must therefore be some other sources of waste not sufficiently recognized, but which it is desirable should be sought after and, if possible, avoided. The demand upon our space will not permit us to say more on this subject here; but we intend to return to it on an early occasion.

THE MARTIN STEEL PROCESS.

Condensed and translated from a paper published by CONSTANTIN PEIPERS, Messrs. Martin's representative in Prussia.

Among the great number of new processes of steel manufacture invented within the last decade, the Martin process has been practically the most successful, and may perhaps in its further development stand side by side in importance with the Bessemer process. Though not attracting attention by any new or peculiarly original idea, it has rapidly come into extensive use by the great practical value it has for certain branches of the iron and steel manufacture.

It was on the 4th of April, 1864, when Mr. Martin, in his establishment at Sireuil, near Angoulème, first succeeded in making cast steel on the hearth of a regenerative furnace. The process was patented in France on the 10th of August in the same year. To-day, five years after this first successful trial, the process is worked in many places in France, and has been introduced into almost all the other industrial countries. The larger establishments accept and fill considerable orders for rails and tyres of Martin steel. Martin, himself, has manufactured gun-barrels regularly and without interruption since 1865. The furnace he uses for this purpose is producing one and a half millions of pounds of steel per year. Thus the process may be considered as a decided practical success. Also the technical journals and the highest metallurgical authorities have expressed their belief in the great future of this process.

The idea on which the Martin process is based is not new. Heath took a patent on it as early as 1839.* Numerous experiments have been made by others in the same direction, but without decisive success. Though Martin is not, therefore, the original inventor of the process called by his name, he has the great and undoubted merit of having found out, by numerous and costly experiments, the right proportions in the construction of the furnace and gas-producer, the most suit-

* Heath's patent of 1845 (see Van Nostrand's Mag., No. 6, p. 547) more nearly describes it.—ED.

able materials for the process, and the best manner of manipulating the same. Martin has given to the industrial world not a mere idea, but a complete method of manufacture, developed in its details, and perfected at a considerable experience.*

The general principle in this process is well known, and can be mentioned here in but a few words. A certain quantity of pig iron is melted on the concave hearth of a reverberatory furnace, together with some slag to cover the iron and to protect it from the direct influence of the air and the gases. Small portions of wrought iron are thrown successively into this iron bath, which operation is continued until a test taken from the furnace shows that the whole mass of iron possesses the softness and other properties of wrought iron. This melted soft iron is finally reconverted into steel by the addition of a well proportioned quantity of pig iron. The heat necessary for these operations is partly furnished by a regenerator connected with the reverberatory furnace. The wrought iron to be added may consist of hot puddle-balls just obtained from a neighboring puddling furnace; or wrought iron scraps may be used, being previously heated in a separate furnace, or by the waste heat of a heating furnace. The product of the process is tapped and run into molds, or cast into any required shape.

We intend to show, by the following remarks, what relative position the Martin process will occupy to the other modes of making cast steel now in use; how its results and products compare with those of the crucible and the Bessemer process; and how the new process, in remedying some of the disadvantages of both the above, fills a gap between them, and can be made useful to both.

It is hardly necessary to mention that the Martin process is a much cheaper method of making cast steel than the usual crucible process. It compares in cheapness, under favorable circumstances, even with the Bessemer process, with which it has in a few instances come into actual competition. Though mostly used as yet for the production of larger masses of steel, the Martin process is capable of producing also the finer and harder kinds of steel for tools and cutting instruments, though not of a very superior quality.

The best crucible steel is made in Westphalia, and partly also in Austria, by melting wrought iron together with cast iron. The same thing is done in the Martin furnace, which is in fact a large crucible, the metal being protected by a layer of melted slag. As, however, this process, when carried out in the crucible, requires but nine per cent of pig iron, the Martin process on the other hand using from 30 to 50 per cent, the products of the latter are liable to be somewhat less pure and of a lower quality than those of the crucible process, when worked with similar raw materials. But this can be remedied to a considerable extent by the use of chemicals, which Mr. Martin has used for this purpose with eminent success. Thus the Martin process will enable the cast steel manufacturers to produce their ordinary kinds of steel, which are the most in demand, at a very much lower cost than before. Another circumstance that will lead them to introduce the Martin process is this, that it offers a greater security for producing exactly the required degree of hardness than the crucible process. The latter uses a good many materials, the composition or qualities of which cannot always be exactly known, and it does not present any facility for testing the product before it is poured. In the Martin process, on the contrary, samples can be taken at any time from the steel or iron bath, and the composition of the baths can be easily altered, until it has obtained the desired qualities. The softest kinds of steel which it is so difficult to produce in crucibles, can be made in the Martin furnace with the same degree of security as the harder kinds, avoiding at the same time all the losses and irregularities often caused by the cracking and breaking of crucibles. It is therefore to be expected that the cast steel manufacturers will, for the greater part of their production, replace the crucible melting by the Martin process.

When compared to the pneumatic process, Martin's method may be said to furnish products equal in quality to the best, and superior to the ordinary makes of Bessemer steel, supposing similar raw materials to be used. This is owing, in the first place, to the above mentioned facility of controling the operations in a Martin furnace. The samples taken from time to time show the condition of the metal at any moment, and indicate exactly the point when the metal resembles wrought iron in its qualities, and when it has to be recarburized by a certain

* If Martin added enough to a process that had been abandoned to make it practicable, the patent for his invention is of course valid.—Ed.

weight of pig iron. After being recarburized the metal is kept in the furnace three-quarters of an hour to effect an even distribution of the carbon, thus insuring a perfectly uniform product. During this time the metal has ample time to complete the boil, to discharge all the gases generated in its interior by the previous reactions, and to settle down, forming a quiet homogeneous bath. After this it pours without bubbling, and produces ingots free from cavities or flaws. A sample taken a short time before pouring gives a perfect assurance in regard to its qualities. The tapping of the metal can be done in a larger or smaller stream, as required, thus allowing of its being poured into large molds or used for small castings, for which it is well adapted.

The fitness of a pig iron for the steel manufacture depends principally on the percentage of phosphorus it contains. As puddling purifies pig iron from phosphorus to a considerable extent in converting it into wrought iron, the Martin process, in using this purified wrought iron must also, from this reason, produce a better quality of steel from the same pig iron than the pneumatic process, by which a purification of this kind is not effected. This makes it possible that the Martin process may be worked with success in districts which produce a pig iron not sufficiently pure to make a good Bessemer steel, and from which the Bessemer process is consequently excluded. The plant required by the latter is, besides, much more expensive.

These considerations may be apt to induce Bessemer works, in whose interest it is to monopolize the production of the larger steel castings, to erect Martin furnaces for the purpose of making such castings of a better quality and more perfect soundness. But the Martin process is, besides, in another respect, of great value to Bessemer works, by its being eminently adapted to use up all their scraps, spillings and cuttings in the most advantageous manner that can be imagined.

The greater the progress and the extension of the manufacture of Bessemer rails and Bessemer tyres, the greater importance will the Martin process acquire, because it is adapted and necessary to work the old materials up again.

The Martin process cannot directly make a good steel from inferior pig iron. The pig iron it uses as such must be pure. But it can use to about equal advantage gray iron, spiegeleisen or white iron. Spiegeleisen, which plays such an important part in all the branches of steel manufacture, is also in the Martin process of a very high value. The results obtained with it, when used for the first bath in the Martin charge, were astonishing, the products combining a great natural hardness and solidity, with a high degree of toughness.

A Martin furnace can be worked together with puddling furnaces to great advantage, in which case a separate heating furnace can be dispensed with. The iron in the puddling furnace can, immediately after the boil, be taken into the Martin bath. This way of operating presents an excellent opportunity for the use of chemicals to purify and improve the products. For the pasty condition of the puddled iron, before being balled, makes it well adapted to be mixed with all kinds of chemical re-agents, which afterwards come in very intimate contact with the steel bath when the iron is thrown into it. Martin has made extensive experiments in this direction with remarkable success, especially in working inferior brands of pig iron. This process offers, in general, greater facilities for the use of chemicals than any other method of making steel, and is therefore highly capable of being improved and perfected by new inventions, which quality still more insures its future importance. S.

RAILWAY DISASTERS—THE CAUSE.

Taking the verdict of the Coroner's jury in the late Long Island Railroad disaster as a text—a broken rail—"The Engineer" observes that such casualties in America are usually attributed to bad Welch rails, admits that much very bad iron has been sent us thence, and concludes, first, that it is "criminal" for American managers to buy iron that they know to be unsafe, and, 2d, that American rails are "ill used." This authority further says:

The exceptionally evil influences to which track is subjected in America may be classed under two heads; defects in the method of laying, and defects in the rolling stock. And here we may add that bad rolling stock causes quite as many accidents in the States as bad track.

As regards defects in the method of laying, it will suffice to state that, with exception of a few first-class lines on which accidents rarely occur, ballasting is nearly unknown. The consequence is a continually

recurring irregular subsidence of the line, which renders it impossible that the rails can be equally supported at intervals throughout their length. In many cases, it is certain that double the proper distance practically intervenes between chair and chair, or sleeper and sleeper.* We need not stop to point out how severe a strain this throws on the rails. Furthermore, fishing is almost unknown, and rails are laid so badly, and keyed into the chairs after so slovenly a fashion † that they are exposed to a great deal of unnecessary pounding and hammering, sufficient under the circumstances to deteriorate any rails. If the substructure of American roads were better we should have fewer complaints regarding the bad quality of superstructure, that is, of the rails.

We have said that defective rolling-stock contributes to the destruction of rails in America, and we may repeat that it is quite as fruitful a source of disaster as the bad quality of rails. We constantly read in the American papers of fearful catastrophes due to the bursting of track. In the great majority of cases rails in the States are broken laterally, not vertically. Now it is claimed for the American bogie car that it, beyond all other machines, runs lightly. How is it, then, that track is so often burst? How is it that derailment is so common an occurrence in the States? We are always told that the fault is in the track, yet it has been proved over and over again that the track was good and sound, and that no ordinary violence must have been exerted to break it. All this while, too, no one has questioned the merits of the American car, with its bogie at each end; yet in this system of constructing rolling-stock there is reason to believe that the seat of much of the mischief lies. The Willow Tree accident supplies us with a case in point. After carefully perusing the evidence, we are led to the conclusion that the verdict we have recorded above is wrong; and one juror, Mr. Pearsall, after the rendition of the verdict, read the following statement as his positive belief in the matter:

"As one of the jurors sworn to inquire into all the facts and circumstances attending the deaths of William C. Rushmore, &c., I do find that the said persons came to their deaths from an accident to the car in which they were passengers, the car being thrown from the track, and from all the testimony in the case I am unable to arrive at the cause of the accident."

And he and other jurors added that they could not find anything peculiarly defective in the road, or likely to lead to the accident. There appears, indeed, to be no doubt whatever that the car which left the track got off first, ran for more than a hundred yards on the sleepers, and then broke a rail. Under such circumstances, it is obviously wrong to say that the bad quality of the rail had anything to do with the catastrophe.

The fact is, that bogies, as often fitted to American railway carriages—we beg pardon, "cars"—are very liable to get off the track. It is not unusual to make the wheel base of each bogie shorter than the distance between the rails. The consequence is, that the bogie runs with a sinuous movement, alternately jostling right and left. The cast-iron wheels are not always properly matched in diameter, and thus a constant tendency may exist for one side of the bogie to outrun the other. The cars are not coupled up tight in the train as with us, and they therefore cannot steady the wandering bogie. No one part of the train is a check on the rest, and therefore the chances of derailment are greatly multiplied. We need hardly stop to point out how severely the "wobbling" of a pair of short bogies stuck at each end of a tremendously long carriage, itself oscillating, must try the lateral strength of any track. Yankee engineers are disposed to laugh at our four-wheeled carriages, and to call us behind the age. We fancy that they would find it worth while just to try some of our rolling stock for a while. They have something to learn yet at the other side of the Atlantic from English engineers.

In conclusion, we may state that a letter on the Willow Tree accident, written by a Mr. Wood, has recently appeared in the "New York Times," which bears American testimony to the cogency of not a few of our arguments, as will be seen by the following extracts:

"As a resident landed proprietor along the line, permit me to write a few words with regard to it. The true solution of the matter is that the driver was going at unusual speed, and the last car oscillated from the track, striking and rebounding from the sleepers as it was dragged along, until it loosened a rail which jumped up and had its end caught in the truck-work of the car, which, still being urged on, bent and broke the rail in five places!

"*The true remedy for such mishaps is proper coup-*

* This is a very unusual defect in American track. Indeed, sleepers are often laid too close for proper tamping.—Ed.

† That is to say, not keyed into the chairs at all, the chair being, in most cases, a mere resting for the rail ends.—Ed.

lers, such as the English have, or better still, Miller's automatic coupling, used by the Erie and other great companies. Horrible as was the loss of life, it is well it was no worse under the circumstances; *but until more effective means of retaining the cars on the track when running at high speed be adopted, such will periodically occur*, though I believe the risk was and is aggravated on the Long Island Railroad by bad spiking, inferior iron, deficient ties, and a scamping of the work generally."

"The Engineer" is obviously not aware that the spread truck is usually employed, rather than the short truck, the defect of which it correctly points out. The merits of a properly constructed truck, as compared with a wheel-base the entire length of a car, are evident on mechanical principles, and besides this, they have been proved on the Canadian lines where the two systems have been used side by side. But the dangers arising from unmatched wheels, and especially from the want of the close, tight coupling of car to car, are very great, and should be more seriously and widely considered by our railway managers.

IRON FOUNDING.

"CASTING IN OR ON" TO THE SAME OR TO OTHER METALS—CONSTRUCTION OF FRAMES AND RAILINGS.

From "The Practical Mechanic's Journal."

When we say other metals, we practically mean cast iron, wrought iron, or steel, for no other metals occurring on the large scale in the arts have fusing temperatures such as admit of the processes about to be referred to being applied to them. Occasionally, though rarely, a few substances, not metallic, may be perhaps usefully treated, by the methods of "casting in or on"—for example, grit-stone or blocks of emery might be run round with cast iron so as to unite these into large grinding plates or cylindric surfaces and the like; but these are out of our way just now.

Whenever liquid cast iron, of whatever kind, is brought into contact with a comparatively cold surface of good conducting material, it is, as we have already seen, more or less "chilled;" its texture is altered, its hardness increased with its absolute cohesion, but its toughness diminished. This occurs more or less whenever a piece of wrought iron, or of steel, or of cast iron, cold or but moderately heated, is laid into a sand or loam mould, and the liquid iron which fills the mould comes into contact with it. Conversely, the wrought iron or the steel (and even less completely, and with somewhat different conditions), the cast iron with which the liquid cast iron has been brought into contact, and with which it has to cool slowly, and at the same rate, have their molecular status changed also. The wrought iron loses in ultimate cohesion and likewise in toughness, and new crystalline arrangements are formed within its mass, which, on the whole, deteriorate it as a structural material. Changes of like character are produced in steel, but not to the same extent, and tend rather to the enlargement of its constituent crystals than to materially injure it as a structural substance.

Theory alone would thus appear to place its ban upon any such operation as "casting in or on," and in some cases the verdict of mere theory would be approved as true, in its application to practice. Yet there are very many cases occurring in the every-day work of the iron-founder and mechanical engineer, in which the convenience and the economy of this method of uniting the metals are so great, and the changes induced upon both so unimportant, that theory is wisely overlooked or overridden in practice. Before alluding to some of these, let us take a glance at some of the cases in which theory *ought* to be our guide here, and in which the neglect of it is nearly certain to bring the practician to grief. This will be the case whenever it is important that the full and undiminished strength and toughness of both metals, the wrought iron and the cast iron, should be preserved.

The "crucial instance" of a case in which this is indispensable may be said to be found in the construction of artillery, machines in which every particle of the constituent material is simultaneously strained in three directions at right angles to each other, and by force suddenly or impulsively applied, and always so great as to bear a large ratio to the ultimate or crippling strain of the metal. Here, then, of all others, is the case in which "casting in" should have been avoided. Yet the method of making cannon by casting bronze or cast iron round a wrought iron or steel interior tube has been again and again proposed and often tried. In the older days of iron metallurgy, when these subjects were less distinctly understood, and when want of good tools gave some strong inducements, on economic grounds this method was excusable. The very same proposition has been but recently revived, however, by Major Palliser; and it was not before a large gun was blown to pieces at, we believe, the first round, at

Woolwich, that the inventor, with infinite candor, publicly declared that thenceforth he abandoned his method (which was not his, in fact), and conceded his adhesion, when too late, to the indications of theory. We are not always called upon to provide for such strains as cannon are exposed to, but whenever the strains upon any machine or structure are severe, and especially when they are impulsive, we shall do well to avoid "casting in."

Yet cases continually occur in practice where, even upon a very large scale, this method of combining the metals by laying the wrought iron into the mould and casting the cast iron round it, may be practiced with advantage and safety.

Thus, for example, in some of the great iron latticed viaducts upon the Commentry and Gannat branch line of the great Orleans system of railways in France, Mr. Nordling, C. E., the engineer-in-chief, has adopted the suggestion made to him by M. Eiffel, the founder and contractor for the iron-work of La Sioule Viaduct, and has united the corner or gusset plates of wrought iron with the cylindrical columns or shafts of the iron piers (which are of vast altitude), by casting the former into the cast iron of the columns. The success of the process appears to be complete in this instance. Here the mass of cast iron in immediate contact with the wrought iron is relatively large. There is, therefore, no very serious deterioration produced in the cast iron, which is the metal the more obnoxious to injury of the two; and on the other hand, the margin of safety allowed in all parts of these structures, and more particularly in the mass of these gusset plates, admits of some deterioration in the wrought iron constituting them, without running any risk.

To pass to the other extreme in point of dimension, we see this method in continual use amongst the founders of ornamental castings, such as light balusters, balcony panels, &c., into the sand moulds for which are laid short pieces of iron rod or wire, which, when "cast into" the extremities of these castings, become the means by which they are united by screw nutting or by riveting with the hand-rails and other parts of the architectural structures into which they enter. Here, as both cast and wrought iron are small in scantling, and the subsequent strains are small, some loss of strength or toughness can be afforded in consideration of economy.

Our chief aim now is to point out how largely and advantageously this method may have its use extended, and to give some examples. Let us first, however, recur in some degree to theory, and in the way of correcting a very prevalent error amongst many who might be presumed to know better, as to what *can* be effected by this method of casting in. It has been supposed over and over again that additional strength and toughness may be conferred upon castings in iron, by including in their interior a wrought-iron skeleton, which the cast iron, when run around it, shall clothe with itself, as the flesh encloses the bones of an animal. Thus, to quote but one example, several years ago, in the early days of railways, the late Mr. George Forrester, of Vauxhall Foundry, Liverpool, patented a method for making improved cast-iron wheels for railway wagons, by riveting or welding together in a rough and cheap way, a sort of skeleton wrought-iron wheel. This was tinned or galvanized, and after having been warmed, was laid in the dry sand mould, and the cast-iron wheel was poured and formed around it.

Such wheels, proved admittedly to be no better than if simply of cast iron, probably were not nearly as good as a well-made American chilled rim cast-iron wheel, and probably were in reality rather worse than the same cast wheels would have been *minus* their wrought-iron bones. It may be accepted as a fact, that no real accession of strength can be thus attained in any casting, if the cast iron be good soft gray or mottled metal; inasmuch as the extension per ton per inch of such, is actually greater than that of wrought iron for the first ton or two, so up to that limit at least the whole strain will come upon the one material only, helped by the slight surface adhesion of the two. Both materials also are in a state of initial strain more or less, dependent upon their diverse coefficients of contraction and their differences of temperature at the instant of consolidation of the cast iron. If, again, the cast iron be rigid and harsh, white or chilled or light mottled iron, then the whole strain is one of the two; and so these wheels, if made hard enough to have a tolerably well-wearing rim or tread, might break all to pieces, and all that the wrought-iron skeleton inside could do would be more or less imperfectly to hold the fragments loosely together. A remarkable and not uninstructive example of this was seen in 1867 at Paris, at the Great Exhibition contest between the bank safes of Mr. Herring and Mr. Chatwood.

The former maker fills the space between the outer and inner wrought-iron or steel plates of his safes with a plate of intensely hard Franklinite iron, poured in while in fusion. This is so hard that it cannot be drilled by ordinary means, but it is also extremely brittle, more so, apparently, than any ordinary white or chilled iron. As an alleged remedy for this, the Franklinite was cast upon or around a sort of network of tough wrought-iron cylindrical rods of about $\frac{5}{16}$-inch diameter, and it was affirmed that these conferred upon their hard and brittle surroundings their own toughness. When, however, plates of this combined material were broken up, which a few blows from a heavy hand-hammer were enough to effect, they proved just as brittle as ever. The dislocated fragments, it is true, or some of them, hung together, though more or less separated, by means of the reticulation of tough wrought-iron wires, and whose toughness did not in this instance seem to have suffered much change; but the plate as a whole broke up readily as before, and admitted of fragments being beaten out of it.

In Mr. Kirkaldy's museum at his testing works, Southwark, is a heavy cylinder of cast iron of very fine quality, in the middle of which is seen a very heavy concentric cylindrical bar of rather rigid wrought iron, cast into it. The original proprietor of this notable compound bar, of whom we know nothing, it appears brought it to be tested, and requested that the proof should be only carried up to some few tons per square inch, the allegation being that the cylinder was of some secret and improved *cast iron*. Arrived at this limit, the extensions appeared so strange to the experienced eye of Mr. Kirkaldy, that he resolved to go on *à l'outrance*, and so broke or pulled the cylinder in two, when, to the disgrace of some "person or persons unknown," the big wrought-iron bar was discovered in the middle. It was *this* bar, in fact, that was bearing nearly all the strain for the first few tons, and the cast iron when broken showed itself no better than common. It was creditable to the experimenter to have thus detected a disgraceful attempt at a *quasi* scientific fraud, but, besides the moral, we may draw also the physical lesson which we have been otherwise inculcating, from the result.

We thus may take it for granted that no increase of resistance, of any industrial value, at least, can be secured by trying to combine cast iron and wrougt iron or steel, by casting in, or one within the other. The advantages of casting in are limited, in reality, to economy, rapidity of execution, and convenience. We shall see that incidentally, however, in the case of wrought-iron structures, such as iron railings, or, as our French readers will better understand, *grilles*, certain additional advantages are secured.

The two following examples will at once illustrate the methods of practically employing the "casting in or on" process, and point out two of the chief classes of manufactured objects to which the process may with most advantage be applied. We shall take, first, the patent secured some years ago by Mr. David Moline, for a method of producing window sashes or frames by combining wrought iron with cast iron. The "muntins" of these sashes are formed of rolled wrought-iron bars in any of the usual rabbated sections fitted to receive the glass. These are cut or shorn off into appropriate straight lengths, equal nearly to the straight (or curved) sides of the panes. An iron pattern moulds the entire sash in the sand; when it is withdrawn, these straight pieces of iron sash-bar are laid into their respective places in the sand mould so that their ends approximate, four such coming together at each intersecting point, if the sash have square or rectangular panes. A boss or *patera* is moulded at each such intersection, ornamented or not, but of sufficient size to embrace the four disconnected ends of the wrought-iron bars, and when cast in iron, to solder or unite these together into one. These bosses are then "poured," either simultaneously by the aid of a compound "runner," or one or more at a time; the sash is then complete, all the loose pieces of "muntin" being so united together. They are extremely strong, may be made very ornamental, and have immense advantages, both in manufacture and in use, over the older sashes wholly of cast iron, in casting which it was always extremely difficult to preserve a light and large "muntined" sash free from bending, distortion, or fracture of some of the "muntins" while cooling, and the whole affair, if large, was so fragile as to scarcely bear transport, and to offer no resistance to violence.

The older and wholly wrought-iron sashes, on the other hand, in which the "muntins" intersected, and were united by "halving" or riveting to each other, were neither neat nor cheap.

Excellent examples of these improved sashes may be seen in the windows of the Ludgate Hill Station buildings of the London, Chatham and Dover Railway Station, in the front of the new Covent Garden Theater, and in many other places in London.

Casting wrought-iron pieces together in this sort of way is plainly not confined to the production of sashes. In fact, it has been employed, with excellent effect, by Mr. Thomas Page, C. E., in the production of two or three different classes of wrought-iron trellis railing, or fence, at the Chelsea Suspension Bridge, London, and its use in this direction might be largely extended with advantage.

The other example to which we shall refer is that of the grand line of *grille* or railing which extends for about 1,600 feet in a straight line, and forms the northern side of Nassau street, in Dublin, separating that from the park of Trinity College. This was designed by and executed under the direction of the writer. It consists of a succession of cast-iron perforated pilasters, of ornamental open work and work in relief, with caps and bases, and sustained by two scroll struts at the rear, at intervals of about 50 feet. These are "cramped," *i. e.* run with an alloy of lead and zinc, into the granite continuous base. The spaces between these are filled up by the *grille*, consisting of a flat wrought-iron horizontal top and bottom bar, each in one length, of upright round bars of wrought iron, and of cast-iron ornaments cast on to the same, which here form structural parts of the work.

In the production of this large quantity of railing, not a single piece of wrought iron was ever heated or put into the smith's fire. The top and bottom bars were rolled to the right length, and punched cold—the top one with $1\frac{1}{4}$-inch holes, all to let the vertical bars pass through them; the bottom one with five successive holes of $\frac{7}{8}$ diameter, and then one of $1\frac{1}{4}$ diameter, alternately. The round bars were ordered in two different lengths, five-sixths shorter (about $7\frac{1}{2}$ ft.), and one-sixth of them longer. Every sixth vertical bar passes through both the top and bottom horizontal bars, and for nine inches into the granite base, into which it is zinco-leaded, the lower end of the vertical bar passing through a hollow cusp, or foot-block, upon the top of which the bottom bar rests. The shorter bars are riveted cold through and at the bottom side of the lower horizontal bar, and pass through the upper one.

All the vertical bars being prepared and straightened perfectly by hand, the one-sixth longer being mere round bars of the proper length, and the five-sixths shorter with the bottom and neck collars, were then laid into sand moulds, in batches of twelve in one "box;" and the bottom and top ornaments, being moulded from hollow iron patterns, made to fit the wrought-iron pattern bars, and to keep their proper places and relative distances by means of steady pins, were then "cast on" to them. The top ornaments and then the bottom ones of each batch of twelve bars were "poured" simultaneously, and the sand was at once stripped off; the bars being all separately taken out, and the thin "gates" knocked off, which was all the dressing these ornaments required, or, indeed, admitted of; for though cast from soft gray pig, they were, by reason of their small relative volume, quite chilled through. Very few broke in cooling; very few were bad castings—and these were broken off from the bar by a blow or two of a hammer, and again others cast on. The hollow or open (as to design) halbert heads which complete the railing at top, were cast in green sand, and cored to drop on loosely to the top ends of the vertical bars, and so admit of being zinco-leaded on to the same.

Now, to erect this railing, the vertical bars were put into position, with the bottom horizontal bar, all laid flat into a wooden framing made to keep them in position and to clamp them so, until the whole sheet was hoisted into place. All the bottom ends of the collared bars were then riveted to the bottom horizontal bar. The "cusps" being in place over the holes "jumped" into the granite base, the whole sheet and frame was hoisted up by two tackles, and the longer bars dropped through the "cusps" into the holes in the base, the ends of the horizontal bar being inserted into the mortices in the pilasters, in which they were held fast, though free to expand and contract within these. The top horizontal bar was then dropped over the tops of the vertical round bars, until it rested upon the uppermost part of the top "cast-on" ornaments. The halbert heads were then dropped over the projecting tops of the vertical bars; the vertical bars, which were in the holes in the stone base, were zinco-leaded into same; the halberd heads were likewise so secured to the tops of the vertical bars, and then that length of railing was complete. A scroll rear strut corresponding with those of the pilasters

was secured at the middle of each length, so that there are thus struts at every five-and-twenty feet, or thereabouts. If we have succeeded in making clear to the reader the processes followed, he will have recognized how small was the amount of workmanship expended in the production and erection of this railing. In reality it did not, upon the wrought-iron portion, amount to more than about 40s. per ton of the material.

The entire economy here was due to the application of the method of "casting on," for that alone permitted of all the other structural details being carried out.

One great advantage resulting from this method of construction is the possibility of dispensing with "leading on" the cast-iron ornaments as commonly practiced. So put on, every lead collar is an electro-negative galvanic element, increasing the tendency of the iron to rust, and causing the corrosion to be local and locally powerful. With many designs it would be practicable to dispense with the use of "cramping" or leading altogether. With that we have described this might have been done, at a little greater expense.

The writer, however, had proved experimentally that an alloy of zinc and of lead may be formed, whose galvanic relations to iron are much more nearly those of zinc itself to iron, than those of lead to that metal, and in fact such as not to cause any fear from its local increase of corrosion on the iron of railing. This alloy he adopted in place of lead, for what he has called the zinco-leading or "cramping" together, and the result has justified his experimental previsions, for after twenty-six years, and not more than four coats of dark green paint during the time, there are no signs of local corrosion whatever. Zinc itself would be best of all as a "cramping" metal, but it runs too thick and drossy to form a close or safe junction.

In some ornamental railing recently erected at Westminster, the uprights are secured without leading to the granite, by iron studs and screws and by Portland cement. This is, however, a bad plan; one may say "out of the frying-pan into the fire," for the bond of the thin plate of Portland cement is certain to be broken by the expansion and contraction of the metal, and then water will find its way in by capillarity, rust will form between, this will, as usual, expand in volume as compared with that of the metal from which it has been produced; and the railing will be lifted up or the base claws broken by it, or by the expansion of water frozen between the joints which it shall have entered.

The points upon which we have here been treating are wholly those of the practical ironfounder, and of the founder in one of his humblest capacities, namely, as the servant of the architect and builder. It is to be hoped that enough has been put before the reader interested in the founder's art, however, to impress upon his mind the advantages he may occasionally derive from the method of "casting on," and to indicate the cases in which and why it should be shunned, and also some of those in which it may be employed with a value and profit proportionate to the skill devoted to its special adaptation.

HISTORY OF DECARBURIZING IRON.

No. V.

MALLEABLE IRON AND STEEL SCRAP AND CAST IRON MIXED AND PUDDLED—ALSO ALLOYING OTHER METALS WITH IRON.

STIRLING, JOHN DAVIE MORRIES.—1848. October 12. No. 12,288.

"Improvements in the manufacture of iron and metallic compounds." The patentee, after referring to his letters patent of June 29, 1846 (see No. 11,262), describes his improvements in the manufacture of malleable iron and alloys of iron and other metals. 1st, in making malleable iron, he adds malleable iron scrap in proportion of from $\frac{1}{20}$ to $\frac{1}{5}$, or even $\frac{1}{4}$ by weight to white pig iron in the pig bed, or otherwise, and the mixture is then boiled and puddled so as to thoroughly incorporate the whole together. Another mode of mixing, which is preferred, is to melt the malleable and cast iron in a suitable furnace, and then run the liquid mixture into the puddling furnace; the expense of refining iron is by these processes avoided. If good qualities of cast iron be employed, larger proportions of malleable iron should be used. Refined iron may, if required, be also combined with malleable iron scrap. Steel scrap also improves the quality of the iron. To produce an alloy of malleable iron less fibrous and harder than the common iron, block tin or groin tin may be added in proportion of from $\frac{1}{200}$ to $\frac{1}{100}$ by weight to any of the above mixtures; bismuth, antimony, and arsenic may be similarly used, and also zinc and copper, which produces a hardening effect, and manganese, which gives a steely character to the iron. An alloy of zinc and iron is produced by introducing zinc into the cupola furnace when the charge has been lately run out; the zinc combines with the iron left adhering to the sides of the furnace, and forms a mixture which should contain from 4 to 5 per cent of iron; if it be found to contain less more iron should be added. The speci-

fication also describes a method of making an alloy resembling gold from zinc, iron, copper, and manganese, which is called British gold; also an alloy of copper and manganese; also an alloy of zinc, iron, and copper, and nickel, and manganese resembling silver.

[Printed, 5d. See "Repertory of Arts," vol. 16 (enlarged series), p 42; "Artizan," vol. 7, p. 231; "Patent Journal," vol. 7, p. 12; "Mechanics' Magazine," vol. 50, p. 381.]

ORE AND SCORIA MOULDED INTO BRICKS FOR PUDDLING FURNACE LINING.

WILLIAMS, GEORGE.—1849. January 13. No. 12,416.

"Improvements in preparing puddling furnaces used in the manufacture of iron." Iron ore and scoria are ground to powder and mixed with water, so as to form a kind of paste. This is moulded into bricks or slabs or other suitable shapes, dried and baked, and used as a lining for the sides and bottoms of furnaces.

[Printed, 6d. See "London Journal" (Newton's), vol. 35 (conjoined series), p. 19; "Mechanics' Magazine," vol. 51, p. 66; "Patent Journal," vol. 7, p. 173.]

PUDDLING FURNACE WITH TWO CHAMBERS; AIR AND STEAM JETS IN PUDDLING.

PLANT, REUBEN.—1849. July 18. No. 12,706.

"Improvements in making bar or wrought iron." The object of the invention is to regulate the heat during the process of puddling iron. A puddling furnace is described having two chambers, a puddling and a preparatory chamber, with a damper between them. Hot or cold blasts of air and jets of steam are used, as described, for regulating the heat in the chambers respectively.

[Printed, 9d. See "London Journal" (Newton's) vol. 36 (conjoined series), p. 173; "Patent Journal," vol. 8, p. 212; "Mechanics' Magazine," vol. 52, p. 61.]

AIR HEATED BY THE BRIDGES AND SIDES OF A FURNACE AND FORCED INTO ITS CLOSED ASHPIT.

PRIDEAUX, THOMAS SYMES.—1849. August 30. No. 12,750.

"Improvements in puddling and other furnaces." Firstly, a puddling furnace is described having a closed ashpit to which air is supplied under pressure. The air is conducted through pipes or passages regulated by cocks or valves under the bottom of the puddling furnace and through the bridges, so that it becomes heated, and the sides and bottom of the furnace and bridges are cooled. The heated air is thus forced into the closed ashpit, and introduced into the furnace, or it may be introduced through openings in the sides of the furnace.

Secondly, a smelting furnace is described, having a fireplace in the front, and behind that a kind of crucible, and behind that a smelting chamber into which the ore is introduced through a hopper. The smelting chamber communicates with a chimney. Air is forced through suitable passages formed in the brickwork ot the lower part of the furnace, and is supplied in a heated state, and under pressure, to a closed ashpit, and thence introduced into the furnace.

[Printed, 10d See "Repertory of Arts," vol. 16 (enlarged series), p. 25; "Mechanics' Magazine," vol. 52, p. 194; "Patent Journal," vol. 8, p. 270.]

PUDDLED STEEL—ALSO, DECARBURIZING CAST IRON BY HEATING IT ENVELOPED IN CLAY, AND BY PASSING AIR OVER IT WHILE HEATED.

RIEPE, EWALD.—1850. Jan. 29. No. 12,950.

"Improvements in the manufacture of steel." These consist, firstly, in a peculiar manner of working the puddling furnace. A charge of about 280 lbs. of pig iron is introduced and raised to a red heat, when the fluid begins to melt the damper is partially closed to lower and regulate the heat. Twelve or sixteen shovelsfull of slag or cinder iron are then added, and the whole melted down. The mass is then puddled with a little black oxyde of manganese, common salt, and dry clay ground together. After the mixture has been acted on for some minutes the damper is fully opened, and 40 lbs. of pig iron (or if the ore be sparry iron ore, 20 lbs.) are added, and melted with the charge at a cherry-red heat; as to this part of the process minute directions are given.

Secondly, pig or alloys of pig and wrought iron are cast into thin bars $\frac{1}{4}$ to $\frac{3}{4}$ inch in thickness, these are enveloped carefully in best plastic clay and heated in a furnace for from one to three days, until they are converted into steel. A suitable furnace is described for this process.

Thirdly, the iron bars cast as above described are placed in a cylinder made of fireproof stones so as to allow a stream of atmospheric air to pass through and touch freely all the bars. The cylinder is bricked up at the end, as described, and the bars heated until they are converted into steel.

[Printed, 7d. See "Repertory of Arts," vol. 16 (enlarged series), p. 222; "London Journal" (Newton's), vol 37 (conjoined series), p. 175; "Mechanics' Magazine," vol. 53, p. 98.]

MAKING STEEL BY MELTING ORE, STEEL AND WROUGHT IRON TOGETHER.

ONIONS, WILLIAM.—1851. February 7. No. 13,496.

"Improvements in the manufacture of steel." These consist in melting certain matters together and running the product into castings directly, and then annealing them. Two parts by weight of hematite ore with four parts by weight of common steel, and 94 parts of iron made from Cumberland or other like ores, are placed in a crucible and melted. The metal, instead of being run into ingots, is run at once into moulds of the required shapes. The castings are then annealed, and are so rendered malleable, when they may be treated in like manner to articles made of ordinary steel. The annealing is carried on in like manner to that resorted to in annealing articles made of cast iron from Cumberland and similar ores, whereby they are rendered malleable. Articles like bars, about an inch square, should be raised to a red heat in 24 hours, and maintained at that heat for about 120 hours, and then gradually cooled. Cast-steel articles so made may be cut or dressed or partially

formed and tempered like articles made of ordinary steel.

[Printed, 3d. See "Repertory of Arts," vol. 18 (enlarged series), p. 331; "London Journal" (Newton's), vol. 39 conjoined series), p. 344; "Mechanics' Magazine," vol. 55, p. 136; "Patent Journal," vol. 11, p. 231.]

NOTE.—*The effect of the small percentage of ore must be to slightly decarburize the iron and steel.*

PIG IRON BOILED WITH ORE AND CARBONACEOUS MATTER MIXED, COOLED IN A SPONGE, GROUND, ASSORTED, REHEATED AND BALLED.

HAZLEHURST, ISAAC.—1851. June 3. No. 13,655.

"Improvements in the manufacture of iron." These relate to the puddling process. The iron is puddled in the furnace with a mixture of iron ore and carbonaceous matter, as ground coal, coke, charcoal, or sawdust. When the iron is puddled the damper is to be lowered until the metal begins to thicken, "it is then boiled and kept very hot until it becomes very thin or liquid." The draught is then "checked until the metal is brought into a state" ready "to ball." It is then drawn out in convenient size, but "without being balled, and placed in a closed barrow, or other receptacle" made to exclude external air, and left to cool. It will then be in a spongy or honeycomb state, and is to be crushed or ground by stampers or rollers; the bad or imperfectly worked iron must be picked out, and as much good iron as will make a bloom is put in a furnace and balled at a low heat, and worked under the hammer or squeezer in the usual way. The iron so made does not require cutting and piling, and is suitable for spades, edge tools, boiler plates, wire, &c. If required to take a polish, the crushed or ground iron should be scoured. The ground iron is also used "for sinking in the charcoal fires, for making iron for conversion into steel," instead of charcoal pig or best scrap iron.

[Printed, 3d. See "London Journal" (Newton's), vol. 30 (conjoined series), p. 282; "Mechanics' Magazine," vol. 55, p. 495; "Patent Journal," vol 12, p. 121.]

FRANKLINITE USED IN THE PUDDLING FURNACE.

JONES, S. T.—1851. September 16. No. 8,357. (U. S.)

CLAIM.—The application of Franklinite to the improvement of iron in the processes of reduction from its ores, and in the finery or puddling of crude or pig iron, according to the methods as above described.

CHROMIUM — ALSO SALT, BARYTA, LIME AND SODA — USED IN THE PUDDLING FURNACE.

STIRLING, JOHN DAVIE MORRIES.—1851. December 22. No. 13,877.

"Certain alloys and combination of metals." This invention is an improvement on that patented by the inventor on January 31, 1851. See No. 13,486. It relates to coating metals, such as iron, copper, tin, &c., with metals and metallic compounds, as tin, copper, zinc, lead, gold, platinum, &c., and their alloys.

Also in improving the quality of iron by adding chromium, by preference, in the condition of chrome iron, or chromate of iron, in proportion of from $\frac{1}{400}$ to $\frac{1}{800}$ of each puddling charge; or it may be added at an earlier stage than the puddling process. When the iron is particularly cold-short or red-short a chloride is added, and common salt, at the rate of 1¼ to 3 lbs. to each charge. The chromate is to be added when the iron is nearly or quite melted, and the softer iron takes more than the harder class.

Also, instead of chromium, baryta, or its salts, by preference, the carbonate may be added to iron, 1 lb. of carbonate to each charge in the puddling furnace.

Also carbonate of lime and muriate of soda, in equal proportions, may be advantageously added to the iron; from 2 to 3 lbs. of the mixture being added to the puddling charge.

NOTE.—*The patent also specifies using lead and chlorides in the blast furnace.*

PUDDLING—THE FIRST PERIOD WITHOUT STIRRING. THE PRODUCT MELTED WITH EXCESS OF CARBON AND REMELTED WITH IRON TO DILUTE THE CARBON.

COLLINS, WM. WHITTAKER.—1852. March 24. No. 14,033.

"Improvements in the manufacture of steel." A communication.

A charge of about 4 cwt. of grey pig iron is "melted in the puddling furnace in the ordinary way, with a large quantity of silicate of iron or other metallic oxyde." The first period of the boiling process is continued without "stirring or raking the metal," as is ordinarily done. The melted mass is thus left quietly exposed to great heat, "by which means the impurities, less the carbon, are burned." This process is continued for from 15 to 30 minutes, according to the nature of the iron. The iron will then begin to rise up, and must be then worked vigorously "under the action of the highest degree of heat," to make it fit, as soon as possible, to be balled up for the hammer or squeezer or rolls.

The product will be pure "close-grained iron," which "either in the state of milled bars, balled iron, or finished bars, will unite with facility with various proportions of carbon." They are, therefore, without previous cementation, "melted in crucibles, with the application of carbonizing substances, by which means cast steel is produced," of which the degree of hardness "may be regulated by the application of carbonizing substances in greater or less quantity."

"A superior quality of cast steel adapted for tools, chisels, &c., is obtained by melting the said bars with a comparatively large proportion of carbonizing substances." The product is a highly carbonized brittle cast steel. "This is to be remelted with fresh parcels of the said iron bars."

[Printed, 3d. See "London Journal" (Newton's), vol. 41 (enlarged series), p. 317; "Mechanics' Magazine," vol. 57, p. 279.]

DECARBURIZING CAST IRON BY HEATING WITH OXYDE OF ZINC OR LEAD, TO MAKE BARS WITHOUT PUDDLING.

BEAUVALLET, JEAN ERNEST.—1852. June 12. No. 14,167.

"Improvements in the manufacture of iron and steel. A communication. These consist in heating cast iron "in contact with a metallic oxyde (or it may be "a carbonate which will act by reason of its oxyde)," and afterwards extending it by hammering or rolling, without the necessity of puddling it. Directions are given as to the way in which the iron is to be cast in bars or sheets, so that the impurities and bubbles may form their ends, and be cut off with the rough ends of the sheets or bars.

For the decarbonization of cast iron protoxyde of zinc and calamine are preferred, but oxyde of lead may be used. A table of proportions is given. The zinc, if any remain, is to be driven off by heat. When malleable iron is to be made, much of the decarbonizing substances must be employed; when steel is to be made less will be required, but the steel should be cemented with charcoal in the ordinary way, to expel the zinc and equalize carbonization.

[Printed, 4d. See "Repertory of Arts," vol. 20 (enlarged series), p. 363; "Mechanics' Magazine," vol. 57, p. 497.]

HARBOR DEFENSE—FLOATING GUN-CARRIAGES.*

BY SIR WM. G. ARMSTRONG.

From the London "Times."

Sir Wm. G. Armstrong calls attention to the value of small vessels (like the "Staunch," designed by Mr. Rendel), for defending seaports against the sudden inroads of hostile ironclads in time of war. The importance of protecting commercial harbors from this kind of attack is a subject which deserves more attention than it appears to receive. The intrusion of an invulnerable war-ship into the port of Liverpool, for example, is alarming to contemplate. Masses of merchant ships closely packed in docks, and large stacks of warehouses containing merchandise worth millions, are objects upon which the powerful shells of modern artillery would produce terrible effect. To prevent the ships of an enemy from approaching our shores would require our fleet to be ubiquitous, and if hostile ironclads cannot be kept at a distance, there is nothing at present to stop them from entering our ports. The experience of the late American war shows that it is very difficult to intercept a steam war-ship on the open seas; and under present circumstances it is certainly presumable that, whether we should happen to quarrel with the United States or with an European power, vessels would be fitted out on the other side of the Atlantic for inflicting every injury upon our property and commerce.

Let us consider, then, what is necessary for the defense of our seaports. We may presume that the kind of vessel which would be used for making a dash at a harbor would be a steamer large enough to unite speed and sea-going qualities with the protection of heavy armor. She would carry guns of great size, adapted alike for engaging and opposing ironclads and throwing enormous shells. She would be rendered secure against boarding, and be protected against small arms. Without heavy rifled guns no impression could be made upon such an enemy as this, and of such guns there are none in any one of our commercial harbors. Supposing, however, the guns to be forthcoming in time of need, we have still to consider how they can be most advantageously applied. We have, in fact, to choose between mounting them on fixed or floating platforms. If we plant them as fixtures, the batteries containing them must be at points where the channel can be commanded within easy range, and where a boom or other obstruction can be thrown across to detain the invader under fire. Without such detention, the time occupied in running past a battery is too short to admit of decisive results. The rapid motion and constantly varying distance of the vessel would make it difficult to hit her in a vital part, even if cool deliberation and judgment were used; but the difficulty would be enormously increased by the hurry and excitement that would prevail among the gunners during the brief passage of an enemy's ship. There is, however, this objection to booms and similar obstructions, that they cannot be so contrived as to be capable of stopping an enemy without at the same time interrupting commercial traffic. Nor is their efficacy as a barrier certain, since it is hard to say what steam an iron cannot break through. So that, altogether, the method of protecting harbors by batteries and booms is not very promising. If we now turn to the other alternative of using the guns afloat, we shall find that the difficulty vanishes. The vessels for carrying the guns need be nothing more than floating gun-carriages, like the little Staunch. This vessel, though a mere barge in point of size, carries a 12½-ton gun, the movements of

* The idea of floating gun-carriages, as here referred to, though well carried out in England, is not of English origin. The "Naugatuck," built by the late E. A. Stevens, and fought in the late war, was merely a floating gun-carriage, the gun (100 pr.) being trained by turning the vessel by means of twin screws. See "Ordnance and Armor," p. 591—ED. *V. N. M.*

which are effected by steam-power, so that a very small screw suffices for working it. The boat is propelled by twin screws, which give her such a power of turning that she can change the direction of her large gun as easily and quickly as if it were mounted on a turn-table. She is incumbered with no armor, because her safety lies in her smallness, which renders her difficult to hit, and because armor is worse than useless when opposed to guns capable of piercing it. Finally, she is cheap. The cost of a couple of ironclad frigates would furnish a hundred Staunches.

Now, to revert to Liverpool as an example, let us see what would be the aspect of the case if half-a-dozen of these gunboats were at hand when an enemy's ship ran into the Mersey. She would there find herself surrounded by six little dots upon the water, carrying among them an armament probably even heavier than her own. They would be so small that she could not well hit them, while she would be so large that they could hardly miss her. She could not run them down, for they would be far too quick at turning, and a retreat under shallow water would always be open to them. If by a lucky shot the enemy were to sink or disable one of her assailants, it would be but one silenced out of six. She, on the other hand, would be equally liable to be sunk or disabled by a single shot, so that the chance of victory would be six to one against her, even if she were as difficult to hit as her adversaries. In short, six such gunboats would probably suffice to baffle the attack of several ironclads, and we might be very sure that no hostile attempt would be made to enter a harbor where it was known that these dangerous watchdogs were kept.

Nor is it merely their mobility within the area attacked that recommends these little vessels. The Staunch has proved herself an excellent sea boat both with her gun on deck and in the hold, into which it can be lowered at pleasure by her mechanism and again raised when required. Such vessels, therefore, could quickly be brought from different ports to any point attacked. Moreover, they would constitute excellent schools of gunnery for the naval reserve men, who might in them, at small cost, gain valuable experience in handling heavy guns. Indeed, I should not despair of a class of naval volunteers being established capable of managing such gunboats, and thus rendering every port self-protective. Again, if we are to contemplate the possibility of aggressive war on our part, these vessels will be quite capable of crossing a sea in company with suitable tenders, and would thus be available for foreign service in case of need, or they would prove valuable auxiliaries for the defense of our naval arsenals, if threatened with attack. When not in use they would be laid up on slips, almost free of cost for maintenance, and they could be launched, armed and manned at very short notice.

In offering these brief suggestions on the subject of harbor defense I do not wish to ignore the great value of torpedoes as aids in guarding the entrance of a port; but these implements cannot be looked upon as superseding the use of artillery for that purpose. Even with the best arranged system of torpedoes, it is not difficult to conceive a mode of attack by which the defenders might be deceived either into exploding them prematurely or upon comparatively valueless ships sent in for the purpose; and once exploded, a new system could not be laid down in the presence of the enemy. In fact, there is no knowing what expedients might not be resorted to for evading or neutralizing their effects. For my part, I am persuaded that nothing would prove so free from objection as small gunboats with big guns. But, whatever difference of opinion there may be as to the best mode of attaining the object, certain it is that at the present time we are prepared with nothing that would have the least chance of proving effectual.

In conclusion, I would observe that the preference I have expressed in favor of guns afloat over guns in fixed batteries has reference altogether to commercial harbors, and does not apply to great naval stations like Portsmouth or Plymouth, where much more powerful defenses are required, and where a combined system of fixed and floating batteries would probably be necessary.

NOTES ON RAILWAY CONSTRUCTION.

BY W. AIRY.

From "The Engineer."

It may fairly be said that in England there are scarcely two railways alike; the country is so diversified and irregular in its outline, and so varied in its soil and geological character, that there can scarcely fail to occur, in the course of the construction of a railway, difficulties peculiar to that railway. Such difficulties may not have been of such importance as to form the sub-

ject of a separate memoir, but they are, nevertheless, important to those who are engaged in such work, and if carefully recorded by the engineer in charge, they would form a most valuable mass of information, and from which a book on railway construction could be compiled far more trustworthy than any work compiled only from theory, or the limited experience of a single individual. For the publication and circulation of such notes there would seem to be no more proper or convenient channel than the columns of the best engineering papers of the day, in which they would be preserved for reference. In the following notes the writer does not profess to confine himself to what may be novel in the methods he adopted, but to record the methods themselves, and the experience gained in the application of them.

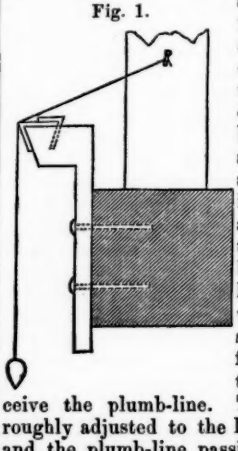
ON SETTING-OUT IN TUNNELS.

There is no ordinary field work so anxious or careful as that which occurs in the steering and setting out of a long tunnel. The chances of error in transferring lines and levels from the top to the bottom of a shaft are considerable, and the carrying on of them properly below ground is also liable to error, from the darkness and the shortness of the base from which to produce the line of the tunnel onwards. Now the accuracy needed in transferring the line of the tunnel from the top to the bottom is according to the number of the shafts; if the shafts are very close together—say, for instance, 100 or 200 yards apart, as they commonly are—the accuracy needed is not exceedingly great, but in proportion as the distance between the shafts increases, so also does the accuracy required, and when, as rarely happens, the shafts are as far apart as 700 yards, the accuracy needed is very great.

In the instance now recorded, a lofty range of hills, which was pierced by the tunnel, precluded the use of numerous shafts; the distance between two of the shafts was more than 700 yards, and in consequence of great difficulties, arising from the quantity of water encountered, the work was much hindered at one of these shafts; so that more than 600 out of the 712 yards between them were pierced from the other shaft, which was comparatively unincumbered with water, before the headings met. For the ranging of this length of 600 yards no method presented itself so practicable as the ordinary process of suspending two lines from the sill of the shaft in the line of the tunnel, and carrying on the line of the heading from the direction so obtained. But as the shaft was only 9 ft. in diameter, and the net distance obtainable between the two lines, so as to allow them to hang perfectly clear of obstructions of all kinds, was only 6 ft. 6 in., it was obvious that unusual care must be taken in the production of so long a line on so short a base. Had the tunnel been straight from end to end, it would have been safer and less troublesome, in this instance, to have ranged the line from the open end, where the heading emerged; but there happened to be a sharp curve at both ends of the tunnel, which would have rendered this method uncertain and indirect.

Now to arrange a line accurately below ground, by means of a pair of lines let down a shaft, it is necessary, first, that the lines should be accurately adjusted at the top; and, secondly, that the direction of the tunnel should be accurately produced from the direction indicated by the lines as suspended. In the instance in question the adjustment at the top of the shaft was managed thus: The center line of the tunnel being truly ranged above ground by the ordinary process, a station on the line was established and carefully marked at a few yards' distance from the shaft; a theodolite was placed over this station, and adjusted so as to range the true line of the tunnel. On each side of the shaft, and in the line of the tunnel, a board, of the shape shown in the figure, was firmly nailed to the sill of the shaft; this board was furnished with a movable nosing of iron, which was tightly clipped down upon the board by iron clips, so as to be firm and secure from shifting, yet capable of adjustment along the nose of the board by tapping lightly at the ends with a hammer. A small notch was filed on the edge of the nosing to receive the plumb-line. The nosing being roughly adjusted to the line of the tunnel, and the plumb-line passing over the notch and down the shaft, the observer at the

Fig. 1.



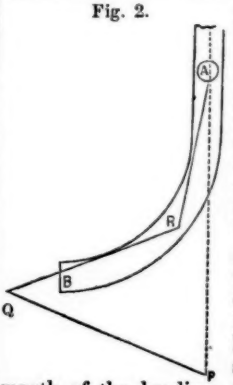
theodolite indicated the true position of the notch to an assistant at the board, by whom the iron nosing was gently tapped with a hammer till the notch and plumb-line were together brought into the true center line of the tunnel. The same was done at the other side of the shaft, and the adjustment at the top was then complete. In this way it is seen that a very high degree of accuracy was obtained, with great security and freedom from accidental shifting of the lines. The plumb-lines were of very strong and fine fish-line, and the plumb-bobs suspended in buckets of water at the bottom of the shaft in the usual manner.

For the production of the line of the tunnel below ground, the following plan was adopted: A stout deal table, on three legs strongly framed together, was firmly planted in in the line indicated by the plumb-lines, and at a distance of about eight yards from them; on this table was placed a theodolite, properly furnished with a lamp for illuminating the wires; this theodolite was placed roughly in line, and adjusted level by the foot-screws. The nearest plumb-line was then illuminated by two men with candles, and the theodolite was pointed so as to bisect that plumb-line, and was clamped fast. The two men then left the front plumb-line, and in like manner illuminated the back plumb-line. This line would appear in the telescope to one side or the other of the intersection of the wires, and the theodolite was shifted on the table to one side or the other, as was indicated by the observation. The whole operation was then repeated anew, and continued until, by successive approximations, the telescope was so truly adjusted to the line indicated by the plumb-lines, that after it had been directed so as to bisect the front plumb-line, the back plumb-line, on being illuminated, remained invisible from the obstruction of the former. Having thus obtained the true line of the tunnel, and carefully clamped the theodolite, the telescope was turned in a vertical plane, and candles were ranged by signal at such distances along the heading as were necessary, and permanent marks established at fixed places for reference.

It may not be uninteresting to know the degree of accuracy which may be insured by the above process. In order to eliminate all chance of accidental error, the work was done three times over from the beginning, at intervals of a month, and on each occasion a permanent nail was fixed in the line ranged at ten chains distance from the shaft. The three nails were driven side by side, and the distance between the two outside nails was $3\frac{1}{2}$ in., thus the limit of error at 30 chains' distance from the shaft would be less than 1 ft. The actual error, as was proved when the headings met, was less than 1 in.

As a check upon the above process, the following plan was used after the heading at the end near the shaft had been driven through to daylight. It is evident that the accuracy of this method depends much upon the number and position of the stations, which the curve renders necessary, as also on the size of the heading, etc.; but it may in some cases be found practicable and useful. Let A B be the heading, A the shaft, and B the open mouth of the heading. Let A P be the line of the straight portion of the tunnel as ranged on the ground, P a station on that line. Take a station at Q, near the mouth of the heading, from which P can be seen, and a station inside the heading at R, from which Q can be seen, and more stations if necessary, until A (a station vertically below the center of the shaft) can be seen; measure by theodolite all the angles A P Q—P Q R, etc. Then, since the fig. A P Q R—A is a closed figure, and all the angles are known except the last angle (in the figure it is P A R), this angle also can be determined. Therefore, planting the theodolite at A, pointing the telescope in the direction A R, and setting off the angle R A P, determined as above, the direction A P is obtained; and by turning the telescope in a vertical plane, the line of the tunnel, supposed in the direction of P A produced, may be ranged with considerable accuracy.

Fig. 2.



There is no great difficulty in setting out the levels of a tunnel. Leveling is such accurate work that an error at commencement does not seriously increase with the distance if moderate care be used. All that is necessary is to obtain pretty accurately the level of a bench mark at the bot-

tom of the shaft; this may readily be done by tying two or more chains tightly together, the chains being first carefully measured, and suspending them from a nail in the sill of the shaft, the level of which is known; with these, and a level-staff to close in the measurement at the bottom, the level of a nail at the bottom may be ascertained to a quarter of an inch without difficulty. The levels may then be carried on by candle-light with great ease to the end of the heading in the usual way. The light of a candle, held near the object-glass of the telescope, though not so as to obstruct the view, is amply sufficient to illuminate the wires; and the staff, when lighted up, can easily be read at five or six chains distance, if the heading be not choked with smoke or otherwise obstructed.

ON THE MANAGEMENT OF CLAY SLOPES.

Very few railways exist which do not at some place or other pass through clay, either in the form of detached beds or pits, such as occur in all geological formations, or else as a recognized formation in itself; and there are no beds which give so much trouble in the construction and maintenance of railway cuttings, except perhaps the beds of running sand holding much water, which are comparatively rare. The varieties of clay beds are wonderful; in the experience of the writer there were found in the short distance of ten miles all kinds of clay, from black shaly clay, which would stand at a slope of 1 to 1 without slipping, to yellow greasy clay, which would barely stand at 3 to 1 (and which the slightest rain rendered very difficult to handle), and again to black rotten clay, which would not stand at 6 to 1, and indeed seemed unwilling to stand at any slope whatever. There seemed to be no principle of general application which ruled the nature of the clay, except that wherever water was present, the clay was worse to handle, and that clay on the sides of hills through which the drainage of the country had to percolate was worst of all. As a rule the clay of the earlier formations was firmer and better than that of the latter, and the black clay was better than the yellow; but the pitch of the ground and the position of the cutting would at any time affect the working of the clay very largely.

When, from the nature of the clay and the local circumstances of a cutting, it is apprehended that the slopes will not stand at the inclination originally intended, there are various methods of proceeding which may be suitable for different cases. The chief of those which were tried in the case of the railway in question were as follows:

1. To get out the slopes to a flatter angle of inclination than was at first intended.

2. To get out the slopes with a curved batter, keeping the width across the cutting at the top the same, or nearly the same, as was originally intended.

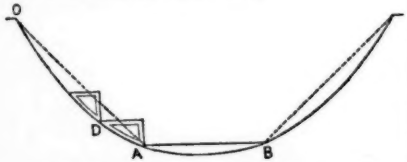
3. To retain the foot of the slope by a low wall, and to flatten the remainder of the slope above the wall by taking stuff from the top of the slope and casting it down against the back of the wall.

4. To drain the slopes, whether by bushes, rubble-drains, or pipes.

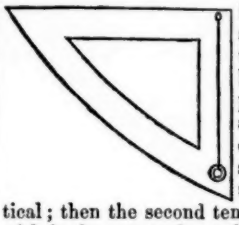
The first of these methods is the most wasteful of all; the labor required in getting out the slopes to a flatter angle is very great, and there is usually a necessity for purchasing additional land, which involves much expense and delay. Nevertheless, in exceedingly bad ground there is nothing else to be done, more especially if the ground be much charged with water, for then the slopes will not bear shaping. But this method will be much assisted by retaining the toe of the slope in some degree; a low wall of rubble-stone well hand-packed will keep a slope quiet at a comparatively steep angle of inclination, which would slip immediately and constantly without it, and give incessant trouble. The wall should be let into the ground to a depth of about 3 ft. below formation level, and if well laid and of good thickness, will save much money in maintenance; it should be of dry rubble-work, to give free passage to the water.

The second method is not commonly practiced, and is too much under-valued. It is rather more troublesome to get out slopes to a curved batter than to a straight one, and in consequence all gangers and workmen have a great objection to using this method; but it is the natural and stable form of the ground when laid to a slope, and the only correct form in which to leave it. In very good ground, which requires only a slope of $\frac{3}{4}$ to 1, or thereabouts, there is no great object in going to the trouble of making the slopes hollow; but as a general rule, a great saving might be effected by it, both in the first cost of the railway and in the subsequent maintenance. As regards the correctness of the above statement, it will

readily occur to all who have had experience of railway slopes, that when a slip takes place in a straight slope, it rarely begins at the top of the slope; a wedge-shaped mass of stuff breaks out from the middle and lower parts of the slope, as in the annexed diagram, and slides down into the cutting; the top remains, sometimes overhanging, and, if not attended to, gradually crumbles away and falls down piecemeal. Such an appearance suggests at once the proper shape to which a slope should be worked, and in one or two instances in the writer's experience the slopes were purposely and carefully worked to curved batters in the following way: The curve selected for the batter was the parabola. What the precise theoretical curve might be is not easy to ascertain, and the conditions of ground vary so exceedingly in different situations, that it would avail us little to know it for any precise case. It is something like a parabola, and as it was necessary to assume some curve or other, the parabola was selected, both as seeming suited to the case, and as being simple in its properties, more especially as regards its area, which is important as offering facilities for the calculation of the cubic contents of the earthwork. The principle on which the curve was applied will be seen from the diagram annexed.

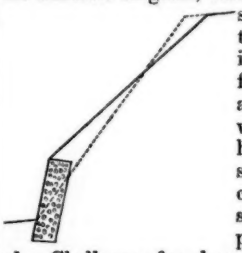


A B is the formation width of the cutting; A C the straight slope; A D C the parabolic slope; the constant of the parabola was so fixed that the two sides of the cutting, when completed, would, if produced underneath the formation, form the entire parabola; the object of this was that, as far as possible, the pressures of the two sides might balance each other without wedging up the formation between them, as sometimes occurs when the batters are straight. For the setting out of the slopes, two curved templates were made and applied as in the figure above. A draft was first traced



in the slope to the straight line A C; then the first, or lowest, of the templates was applied, and the draft deepened till the outside edge of the template was vertical; then the second template was applied, with its lowest angle at the point where the first template left off, and the slope in like manner dressed off till the outside edge of the second template was vertical. The slope being thus started true to curve, the rest of the draft could be completed with sufficient accuracy by eye, and the cutting got out between the drafts in the usual way. The above method is fairly simple and easy, and the cutting is far more secure than when the slopes are flat. This was curiously exemplified in one case where the slopes of a cutting had been dressed as above, except at two points where the batters were left straight from some accident; at both these points a slip took place in the following winter, while the rest of the cutting remained secure. As a general addition to the security of a cutting, this second method is the most correct, and involves the least expense.

The third method is very useful and convenient; the application will be seen from the annexed diagram, where the dotted lines



show the state of things as at first intended, and the full lines the amendment. The wall may be of any hard stuff, big and small together, except the face, which should be of large pieces, hand-packed. Chalk was found excellent for retaining the yellow clay, and the expense of such rough work is very insignificant. The great advantage of this method is that it involves very little, if any, removal of stuff in wagons, and the work can therefore be carried on without blocking the way. The wall should, if possible, be got in before the cutting has slipped much; if the slopes have slipped in, and the clay is much mixed with water, it is very difficult to keep the clay out of the wall, and to make good work.

With respect to the fourth method, so far as the writer's experience went, it is useless to attempt to save a cutting from slips by draining the slopes during construction. For the maintenance of completed railways it is, of course, necessary to allow free passage to the surface water; but for this purpose surface drains are sufficient, and the introduction of deep drains into clay slopes is in general most injurious; the deep drains do in fact, in most cases, lead the water into the body of the slopes, instead of keeping it out; the continuity of the ground is injured, and slips take place in consequence of the drains. Moreover, deep drains are very apt to get choked, especially when any slight motion is taking place in the cutting, and immediately a body of water collects, to the great injury of the slopes. The work of laying in deep drains is very costly, and in no one instance on the railway in question did it stop the progress of a slip for a single day; bushes, large rubble drains, and pipe drains were all employed, but without the least effect, and the slopes had either to be got out flatter, and the stuff removed in wagons, or retained by a rubble wall, according to the third method here given.

If different beds are met with, special methods must be used, as benching the slopes at places, which may sometimes be done to great advantage. The weak point of a cutting is the toe of the slope; it is usual to cut a grip on each side of the way to run off the water, and this grip often seriously undermines the slopes, and causes many slips. This may be to a great extent prevented by using pipes instead of open grips, and covering them over with loose stones, taking care also to provide gulley-holes to catch the dirt which drains into the pipes, and would otherwise choke them; but the best way of protecting the toe of the slope is to build a stout rubble wall, as suggested above in method No. 1. Without some such protection the slopes are in continual danger for long after they are made; they may stand the first winter, and even the second, without giving the least sign of a slip, and yet slip for nearly their whole length at the third winter, and give great annoyance. This, no doubt, is often due to the effect of weathering on the clay; but from whatever cause it arises, it at least shows that the work which is sufficient for temporary stability, does not always suffice for the permanent security of the cutting.

Experiments on Plate Heating by Liquid Fuel against Coal, made at Chatham Dockyard, May 26, 1869:

Number of experiments.		Dimensions of furnace.	No. of grates.	Grate surface.	Description of plate.	Dimensions of plate.	State of furnace when put in.	Time of lighting or putting in plates.	Time of drawing plate.	Time employed in heating plate.	Combustible used.	Quantity of ditto.	State of plate when taken out.
								a. m.	a. m.	h. min.			
1	Oil furnaces.	2.70 ft. × 5.0 ft. × 2.0 ft. high.	None	7 holes ¾ in. diam.	Armor.	7.3 ft. × 3.6 ft. × 6 in.	Cold furnace and cold plate	8 30	10 30	2 0	Creosote oil.	In heating the three plates, Nos. 1, 2 and 3, 67 gals., weighing 705 pounds were used.*	White hot; considered more than sufficient for bending; very equally heated.
2		The same.	"	"	Armor.	9.42 ft. × 3 ft. 3 in. × 6 in.	Hot from the preceding trial	p. m. 10 55	p. m. 12 5	1 10	"		White hot; considered a very good bending heat.
3		The same.	"	"	Keel plate	10 ft. 10 in. × 3.0 ft. × 1¼ in.	"	p. m. 2 0	2 16	16	"		Very white; flattened when laid down by its own weight.
4	Coal furnaces.	21.0 ft. × 5.0 ft. × 2.6 ft. high.	2	16 ft.	Armor.	Same as in experiment No. 1	Cold furnace and cold plate	a. m. 8 0	12 50	4 50	Hartley main coal.	19 cwt.	About two-thirds of this plate were at an annealing heat; the part next the grate only was sufficiently hot for bending.
5		The same.	2	"	Keel plate	Same as in experiment No. 3	Hot from the preceding trial	p. m. 1 50	2 51	1 0	"	3 cwt.	Two-thirds of the plate were nearly white hot, while the other part could not be flattened by hammering.
6		17.0 ft. × 5.0 ft. × 2 ft. high.	3	19 ft.	Armor.	Same as in experiments Nos. 1 and 3.	Cold furnace and cold plate	a. m. 8 30	1 5	4 35	"	19 cwt.	Better heated than in experiment 4, but still unevenly heated, and for the greater part not sufficiently hot for bending.
7		The same.	3	"	Armor.	Same as in experiment No. 4	Hot from the preceding trial	p. m. 1 25	4 15	2 50	"	12 cwt.	Altogether insufficient; an annealing heat only, and that very unequal.

* One cwt. coal was employed in heating generator from which the creosote vapor was supplied.

NEW BRIDGE OVER THE THAMES.

From a paper before the Civil and Mechanical Engineers' Society "On the bridge over the Thames carrying the West London Extension Railway." By Mr. LAWFORD, M. Inst. C. E.

This bridge consists of five segemental arches of wrought iron, each arch having a span of 144 ft. on the skew, with a rise of 16 ft. or 1-9th of the span. There are also, on the Middlesex side of the river, six, and on the Surrey side four, land arches of brickwork, each with a span of 40 ft. and a rise of 10 ft. The total length, therefore, of the structure is 1,270 ft. The abutments and piers of the five main openings are massive pieces of masonry, and are carried to a depth of 36 ft. below Trinity highwater mark, and 14 ft. below the bed of the deepest part of the river. The soffit of the arches at the crown is 22 ft. above Trinity high-water mark, in accordance with the requirements of the Admiralty. The level of the rails is 26 ft. above Trinity high-water mark. The width of the river between the two abutments is 776 ft. on the skew and 706 ft. on the square. The width of waterway afforded is 720 ft. The angle at which the bridge crosses the river is 75 deg. The greatest depth of water is 22 ft. below high-water, the average rise and fall of the tides at this place being about 13 ft. 6 in.

The piers were constructed in coffer dams, the inner row of piles being 5 ft. from the outer edge of the lowest course of masonry, and were driven to a depth of 15 ft. below the bed of the river; the outer row were 5 ft. from the inner row, and were driven to a depth of only 8 ft. from the same point, the space between the two rows of piles being filled with puddled clay. At the conclusion of the work the outer row of piles were drawn, but the inner row of piles were cut off level with the bed of the river. As the masonry of the piers proceeded, the space between them and the piles was filled with puddled clay, well trodden in to a height of 3 ft. above the bed of the river. Each pier stands on a bed of concrete 2 ft. thick, extending 3 ft. beyond the lowest course of footings. On the concrete is laid a course of York landings, 1 ft. thick, and projecting 1 ft. beyond the footings.

The foundations are carried up in a brickwork to within 2 ft. of the bed of the river, where there is a through course of stone 2 ft. thick. From this point to the springing of the arch the pier is faced with picked face ashlar of Bramley Fall stone. There is a second through course of stone half way between the bed of the river and the springing, and the upper, or last 7 ft. of the piers, including the springers, which are 3 ft. thick, are entirely solid stonework. The two abutments are built similarly to the piers, except that they have hollow chambers, filled with gravel to a height of 3 ft. above the springing of the arch; each abutment being just on the edge of the river required only half a cofferdam for its construction. All stonework of both piers and abutments above springing height is tool dressed. The concrete used in this bridge was composed of five parts of gravel to one of blue lias lime, and the mortar of two measures of sharp sand to one of the same sort of lime.

Each of the river arches is composed of six wrought-iron ribs, arranged in pairs, 2 ft. 6 in. apart from center to center. The arch or voussoir of the four main or inside girders is formed of $\frac{3}{8}$-in. vertical plates, 39 in. deep at the springing and 24 in. deep at the crown, with double angle irons, each 4 in. by $3\frac{1}{2}$-in. by $\frac{1}{2}$ in., top and bottom, to which the flanges are attached by means of rivets. There is also a packing strip 8 in. by $\frac{1}{2}$ in. between the angle iron and the flanges. The flanges consist of two $\frac{3}{8}$ in. plates, 18 in. wide. The upper member of the inside ribs is a horizontal parallel girder, similarly constructed, but only 24 in. deep, throughout its entire length. The vertical web is $\frac{1}{4}$ in. plate from the pier to the point where the upper and lower member intersect, *i. e.*, 15 ft. from the center of the arch, and from this point both vertical webs are $\frac{3}{8}$ in. in thickness. The bottom flange of the horizontal girder consists of one plate $16\frac{1}{2}$ in. wide by $\frac{1}{2}$ in., two angle irons $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in., and a packing strip 8 in. by $\frac{1}{2}$ in. The upper flange is 15 in. wide, all other dimensions being the same as those of the lower flange; but the top plate is slightly curved inwards towards the rails. In the two outside ribs the voussoir is constructed as already described, but is 30 in. deep at the crown and 39 in. at the springing. It may be as well to mention here that in these two girders, on the outside faces of the arch, all the rivets, excepting those in the angle irons, are countersunk, no cover plate either being visible at the joints. The whole centre web presents, therefore, the appearance of one smooth unbroken plate. This center web is $\frac{3}{8}$ in. plate, the two flanges are single $\frac{1}{2}$ in. plates 16 in. wide, the angle irons $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in., and the packing pieces 8 in. by $\frac{1}{2}$ in. The

upper member is constructed in the same manner as that of the inside rib, but it has throughout the whole span $\frac{1}{4}$ in. vertical plates, and is only 18 in. deep at the crown of the arch. The upper flange is 18 in. wide, and is parallel with the lower flange, which is only 15 in. wide. The angle irons and packing pieces are of the same dimensions as those already described for the inside top members. The total depth of the girders, both inside and outside at the center of the arch, is the same, viz., 48 in.

The sectional area of each of the four main girders is as follows:—In the arch at the springing, 80 square inches; in the upper member do., 43 square inches—total, 123 square inches; and at the center of the arch, where the upper and lower members are together, 105 square inches, the mean average being 114 square inches. These are the full sectional areas, including the rivets. The voussoir and the upper horizontal girder of the four main girders are connected together by a lattice spandrel, composed of H-iron, of three different sizes, viz., 7 in., 6 in., and 5 in. by $\frac{1}{2}$ in. A stiffening bar of flat iron, $\frac{3}{8}$ in. thick, is added to each side of the H-iron, connecting the lattice bars throughout at the angles of intersection. In the outside girders the lattice and stiffening bars are all made of double T-iron, riveted together, thus $\frac{\text{I}}{\text{T}}$, and of the same dimensions as the H-iron. *i. e.*, 7 in. by $3\frac{1}{2}$ in., 6 in. by 3 in., and 5 in. by $2\frac{1}{2}$ in., all $\frac{1}{2}$ in. iron. Each pair of ribs is connected near the haunches by means of frames, composed of angle irons, cross-braced and riveted to the ribs, forming an open box girder. This principle is continued to the crown of the arch, where the voussoir and top girder unite in a double cell. Each pair of main girders are braced together at the haunches by means of trellis transverse girders 2 ft. 6 in. deep, carried up at equi-distant intervals to within 10 ft. of the center of the arch. There are seven of these in each half arch; they are composed of angle and bar iron, $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in. The top members of the main ribs are secured together by the cross girders, which carry the roadway; the are fixed over the whole length of the bridge, 4 ft. apart from center to center, and are composed of a middle web of iron, 10 in. deep and $\frac{1}{2}$ in. thick, the bottom of which is flanged with double angle iron, $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in., and the top by double channel iron, on the lower flange of which the buckle plate flooring rests. The cross girders rest on the lower flange of top main girder, and are secured in their places by iron knee-pieces, riveted through the center webs. The main or bearing girders are again cross-braced by diagonal rods, bolted to a center plate, and to brackets riveted on to each of the angles. There are three sets of these tie-rods in each half arch.

Upon the end of each arch or voussoir a plate of cast iron, 3 in. thick, is fixed, the back of which is planed quite true and even. These, again, fit into heavy cast-iron shoes (weighing 2 tons each), let into the stone skewbacks of the piers and abutments, and by means of wrought-iron wedges are finally adjusted in their seats. Contraction and expansion are provided for as follows:—Cast-iron standards are bolted to the stonework of the piers and united by a cast-iron frame, secured with bolts and nuts. These standards have recesses to receive the ends of the horizontal girders, and secure them in position, at the same time allow for horizontal motion. A bed and bearing plate, planed perfectly parallel, are fixed under the ends of the horizontal girders, upon which they slide.

The railway is a double line of mixed gauge, and is carried over the bridge by means of longitudinal timbers with transons every 10 ft. Ash ballast is used all over the bridge. A cast-iron moulding is attached to the horizontal girder, throughout its whole length, and a cast-iron plinth is bolted on to the top of the same; an ornamental cast-iron parapet is fixed on the plinth, and the whole is surrounded by a wooden hand rail. In the experiments made for testing the quality of the iron, it bore a tensile strain of nearly 18 tons per square inch, without showing any signs of fracture.

The width of the bridge between the cast-iron parapets is 30 ft. in the clear. The total width of the piers from out to out above springing level is 35 ft. 6 in., and at that level, including the cut waters, 53 ft. 6 in. The total cost of the bridge was £104,000, or £82 per lineal foot, and £2 10s. per superficial foot. The materials used in its construction were 2,000 cubic yards of concrete, 11,100 cubic yards of brickwork in mortar, 130,000 cubic feet of stone, 2,160 tons of wrought iron, 366 tons of cast iron, 2 tons of lead, and 28,000 cubic feet of timber, exclusive of the piles. This bridge was the joint design of Messrs. Baker and Bertram, the chief engineers of the Great

Western and North-Western Railways. It was opened for public traffic on March 2, 1863, since which date some hundreds of trains have passed over it daily, and I am not aware that, up to the present time, any expense whatever—beyond the maintenance of the road—has been incurred, either in repairs or otherwise. The bridge was only 15 months under construction, *i. e.*, from the time the first stone was laid until a locomotive passed over the river. The bridge was very severely tested on January 7, 1863, by Captain Tyler. The narrow gauge load consisted of two locomotives and tenders, funnel to funnel, and two tank engines; total length of train 132 ft., total weight 176 tons. The broad gauge load consisted of two tank engines, in the same position as the narrow gauge engines, each drawing six loaded coal wagons; total length of train 276 ft., total load 292 tons; these two loads, collectively, being equal to about 2⅓ tons per lineal foot. First, the narrow gauge load passed over No. 1 arch at speed, the deflection 5-100ths of a foot. Second, the broad gauge load passed at speed—same result. Third, the broad gauge load on one road and narrow gauge on the other, both passed together over No. 2 arch at speed. On going over No. 1 arch, No. 2 rose 3-100ths of a foot. On going over No. 2 it deflected nearly 10-100ths of a foot, rise and fall 13-100ths of a foot. Fourth, both loads were brought to rest on No. 2 arch, deflection 11-100ths of a foot. When the loads passed slowly over No. 3 arch, No. 2 rose 2-100ths of a foot, rise and fall 13-100ths of a foot. Both loads remained stationary for some time on this arch, but no further deflection took place, and, with the removal of the load, the girders rose simultaneously to their original height. Fifth, the same thing was done on No. 3 arch with a precisely similar result. Sixth, the same experiment was made on the fourth arch, and in exactly the same manner as the fourth experiment—rise of arch 2-100ths of a foot, deflection 10-100ths of a foot, rise and fall 12-100ths of a foot. Seventh, the same thing was done on the fifth arch; the rise was 2-100ths of a foot, deflection 8-100ths of a foot, rise and fall 10-100ths of a foot. The bridge was very steady throughout these experiments, and there was very little lateral vibration, even when both loads passed at the same time in the same direction, either slowly or at speed.

CEMENT FOR ROAD MAKING.

From the "Building News."

If there be one thing in ordinary life in which we seem to have made little improvement in late years, it is surely road making. Compared with the numberless improvements effected in all other directions, it may seem strange that we have learned so little wisdom in reference to this important public convenience. Our thoroughfares are, sewers and drains excepted, very much what they formerly were. The traffic has immensely increased; the wear and tear have proved proportionately great, while the difficulty of interfering with the traffic to execute repairs or renewals has grown more perplexing. Streets are constantly being pulled up, much to the inconvenience of the public, and most of all to shopkeepers; while newspaper complaints have become so customary that few persons heed them, and no one ventures to act upon them. We think the whole subject of road making deserves full and scientific inquiry, and he will be a public benefactor who can lead Englishmen* to improve their methods of laying down roads with greater facility, and of making them less perishable.

It is not because we think the use of Portland cement for road making will effect all we want that we direct attention to its employment for our public thoroughfares. By many it is at present regarded as little else than a novelty, and may, perhaps, be so considered for some time to come. A few years since Mr. Joseph Mitchell, until recently a general inspector of roads and bridges in the northern counties of Scotland, paid particular attention to the subject of macadamized roads. The cost of maintaining these roads, it is well known, is a considerable item in all local accounts. He made experiments which proved that a cubic yard of macadamized stone, when well pressed down in a box with a capacity of 27 cubic ft., contains 11 cubic ft. of vacuities; and that a roadway covered with 12 in. of metal, before it is consolidated into a smooth and useful surface, has a large portion of its stones crushed into small particles. He also discovered that more than one-third of its dimensions consisted of mud and sand. The result consequently has been that the stones in such a roadway, where the traffic is heavy and wet weather frequent, disintegrate to a very

* If the subject is unsettled in England, what is it in America?—Ed. *V. N. M.*

great extent; the greater the traffic, the greater the quantity of mud generated. Six or twelve months' traffic will play sad havoc in most of our public thoroughfares, as we all know; and not even the hardest stone can stand the heavy traffic of our great cities and towns. The ordinary mode of laying down streets accounts for much of this failure. We have before now denounced the loose methods which obtain throughout the country in reference to this matter. Nothing seems more absurd or primitive than to lay the granite in a bed of sand, beating it down a few inches, and then covering the interstices with sand that the first rainfall will speedily reduce to mud or wash away. And yet this is the ordinary process of constructing roadways, a process which necessarily leads to each stone being insulated, and, resting on a yielding surface, to give way very speedily. Mr. Mitchell found that in a street so constructed the ends of the causeway stones were worn down after twelve months' traffic from one-half to three-quarters of an inch. This, of course, arose from the fact of the percussion of the wheels of carts and carriages falling from the center of one stone on to the joint of the two adjoining, which sank from the pressure. "When a stone," he says, "has sunk bodily from one-half of an inch to an inch, or when a little hollow occurs in the pavement of the street, it will commonly be found that the adjoining stones are much worn, the hollow on the surface increasing the force and effect of the percussion of the wheels. The greater the hollow the greater is the tear and wear from the strokes of the wheels."

It was these and other facts which led Mr. Mitchell to consider the propriety of using Portland cement for roadways. Mr. Mitchell's plan is exceedingly simple, and its simplicity commends it to all minds. He first lays down a bed of cement concrete three inches deep, instead of providing a yielding surface. In cases where gravel is more easily procured and is cheap, it may be used instead of macadamized stone. The concrete soon gets firm, and of course excludes all moisture from below. He then places the paving-stones on this base, and, when brought to a perfect form, the joints are filled with cement grout. The paving-stones are five inches deep and three inches wide, a width of three inches being found to give a better hold to the horses' feet than the ordinary widths of 4 or 4½ inches. He holds that when properly consolidated such a surface is perfectly immovable to traffic and impervious to moisture. If, he adds, the causeway be well made, no irregularities on the surface should occur; when they do exist, it is attributable to defective workmanship.

This plan has been tried in three places with varied results, in the first case, at Inverness, in 1865; and at the end of two years, having been subjected to a heavy goods traffic, the road was perfectly sound, requiring no repairs, and presenting a marked contrast to the macadamized roadway adjoining it. The second attempt, in London, is an admitted failure. In this case the traffic was much more severe and trying. Mr. Cowper, the then Chief Commissioner of Works, consented to the inventor laying down 100 yards of his new road on the Mall in St. James's Park, at the foot of the Green Park. The surface subsequently broke up under the heavy traffic, much to the surprise of the inventor. For some time he was puzzled, but at last he solved the mystery. It would appear that the roadway at each end of the experiment was macadamized at the time when the experiment was made, and inadvertently the contractor's workmen were allowed by the person in charge to pass their roller from end to end before the cement was properly consolidated. The consequence was that the crystalline structure of the cement being injured, the surface of the road was found to need repair through its yielding to the incessant traffic. It appears to have been repaired by a coating of two inches of macadamized stone, which was rapidly ground down on the hard concrete by the vehicles. Mr. Mitchell observes in his account of the failure of this experiment: "As the bottom was entire and consolidated, had a coating of two or three inches of concrete been laid down, with the required time to consolidate, it would have answered all the purposes contemplated, but the surveyor deemed it his duty to remove the concrete surface entirely, which was only done at great trouble by means of levers and iron crowbars."

Mr. Mitchell was, however, not to be beaten. All inventors must provide against failure in the early history of their improvements, and the lesson derived from the experiment made in the metropolis was, and will be, of use to him in the future. His third attempt was at Edinburgh, at St. George's bridge, and at the end of twelve

months the roadway was reported to be sound and immovable, notwithstanding the heavy traffic which it is well know passes over this important thoroughfare. One little failure, however, occurred, through inexperience. Small hollows showed themselves at the end of the winter, at the joinings along the center of the roadway. These hollows were soon filled up, and the result has since been eminently satisfactory.

It has been objected to these pavements that they produce more noise than the ordinary roadways; but, while admitting this, it is urged that the noise from the vehicles, though greater, is different, being more of a ringing sound, as if the street were bound up with frost.

The question of cost is an important consideration. It would seem that the concrete road at Edinburgh cost 6s. 8d., and the paved road 17s. per square yard, in addition to 1s. 8d. per square yard for excavating and removing the old road, and watching. It must be remembered that the roadway was but small, and had the experiment been on a larger scale, the cost might have been considerably less. The cement being cheaper in London, the cost of concrete roads would be proportionately less. A firm of engineers in Edinburgh made experiments on Mr. Mitchell's roadway, by which they discovered that it enabled loads to be drawn at a much less cost in tractive power. Thus, we are told that, as the result of the superior evenness and solidity of the roadway, a wagon of two tons' weight ascending a gradient of 1 in 80 required a traction of 70 lbs., while on a common macadamized road, the same weight required a traction of 140 lbs. The difference of one-half is, of course, a wide one. Again, on a road with wheel tracks through new metal, 340 lbs. were required; and on a road newly covered with metal, 560 lbs., all the gradients being 1 in 80. This point of the conservation of power is an important one, and speaks favorably for the new road.

Undoubtedly almost everything depends, in the construction of these roads, upon the quality of the cement and the carefulness with which the work is superintended and done. The inventor holds that the Portland cement should be of the best quality, and tested to bear a tensile strain of 500 to 600 lbs. on a bar $1\frac{1}{2}$ in. square. The cement must be allowed time to harden; a month was found sufficient in Edinburgh. This adds to the difficulty of using the material in the metropolis, where the roads are reqnired for use immediately they are laid. It has been suggested that cement blocks, properly tested, should be used, and this would obviate the difficulty we have pointed out. At any rate, we hope that Mr. Mitchell may yet be permitted to make another experiment in London, where we have reason to believe it would be as successful as in Edinburgh. Mr. Reid, C. E., has expressed his opinion that an engineer might, with duly prepared and tested cement blocks, re-lay the whole extent of London Bridge in fourteen days. Such an event may not be altogether impossible.

THE METRIC SYSTEM.

From a lecture by the Rev. Joseph A. Galbraith, F. T. C. D.

From the "Scientific Opinion."

The jurors of the International Exhibitions of 1851, 1855, 1862, and 1867, all agreed to recommend the general adoption of the metric system by civilized countries. The International Statistical Congress, held at Brussels, Paris, Vienna, London, Berlin, and Florence, reported in favor of its adoption. There is a permanent committee of the British Association, called the Metric Committee, whose object is to forward the adoption of this system, for the sake of the benefit it would confer upon scientific investigators, engineers, and students in the various arts and sciences.

The metric system is, at present, used throughout Europe and America by a population of 150,000,000 of people. Nearly 60 per cent of the total export and import trade of the United Kingdom is carried on with people using the metric system.

The fundamental principle of the metric system is that it should be international. This appears from the report of the Academy of Sciences, signed by its president, Cordorcet, and presented to the National Assembly in March, 1791, by M. Talleyrand. The report states that, after careful consideration of the question, the Academy had come to the conclusion, that every arbitrary considertion should be excluded from the proposed system; that it should not possess any feature which could raise even a suspicion of the particular interest or influence of France. In a word, the Academy desired so to frame the system, that if its principles and details alone, apart from its history, should descend

to posterity, it would be impossible to divine by what nation it was designed or executed.

COUNTRIES IN WHICH THE METRIC SYSTEM HAS BEEN WHOLLY ADOPTED.

	Population.
France, with Algiers	40,500,000
Belgium	5,000,000
Netherlands and Colonies	23,000,000
Italy	24,000,000
Papal States	700,000
Spain and Colonies	21,000,000
Portugal and Colonies	8,000,000
Greece	1,200,000
Mexico	8,000,000
Chili	1,600,000
Brazil	8,000,000
New Grenada	2,000,000
Other South America Republics	3,000,000
	146 000.000

COUNTRIES IN WHICH THE METRIC SYSTEM HAS BEEN PARTLY ADOPTED.

	Population.
Switzerland	2,500,000
Hanse Towns	500,000
Denmark	3,000,000
Austria	37,000,000
	43,000,000

COUNTRIES WHERE IT IS PERMISSIVE.

	Population.
United Kingdom	29,000,000
United States of America	31,000,000
Prussia and North Germany	30,000,000
	90,000,000

Principles and Nomenclature of the Metric System.—1. It is international. Its framers intended it to be so, and so well carried out their principle, that nearly 200,000,000 people have already adopted it.

2. Its principal units are derived from natural standards; the dimensions of the earth, and the weight of water.

3. It is rational, because all its parts, proceeding regularly from the unit of length, are connected together by rational relations.

4. It is decimal, that is to say, all its parts are multiples or submultiples of the number ten on which our arithmetic is founded.

5. The nomenclature is simple, expressive, and well adapted for international use. It consists of only eleven words. The name of each weight or measure tells its own story, and as all the words are derived from the Greek and Latin languages, in which all civilized countries have an equal interest, no national sentiment is interfered with.

Unit of Length.—To establish the unit of length, the Commission appointed by the French Government proceeded to calculate the length of a quadrant of the earth, from the measured length of an arc of the meridian, the extremities of which were Barcelona and Dunkirk, stations which are nearly north and south, and comprise about 10° of latitude, situated very nearly equally on each side of the mean latitude 45° north. The linear standard used in this survey was the toise of Peru, so called from its having been used by Lacondamine, in the year 1756, in the measurement of the Peruvian arc. This toise or fathom was divided into 6 ft., the foot into 12 in., and the inch into 12 lines. The calculation founded on the measurement of the Barcelona-Dunkirk arc gave as the length of the quadrant of the meridian 5,130,740.75 toises, from which the number of lines may be calculated as follows:

5,130,740.75	Toises.*
6	
30,784,444.20	Feet.*
12	
369,413,330.40	Inches.
12	
4,432,959,964.80	Lines.

The ten-millionth part of this was selected as the meter or unit of length. Therefore

Meter = 443.296 Lines.

Unit of Land Measure.—The unit of land measure is the are, and is equal to a square having for its side a line of ten meters.

Unit of Capacity or of Liquid and Dry Measure.—The unity of capacity is the liter, and is equal to a cube having for its side one-tenth of a meter.

Unit of Weight.—The unit of weight is the gram, and is the weight of a cube of cold water having for its side one-hundredth part of a meter.

Multiples and Submultiples.—The multiples of these units are expressed by prefixes taken from the Greek language, and are as follows:

Deca,	signifying	Ten times.
Hecto,	"	Hundred times.
Kilo,	"	Thousand times.
Myria,	"	Ten thousand times.

The submultiples are expressed by prefixes taken from the Latin language, and are as follows:

Deci,	signifying	Tenth part.
Centi,	"	Hundredth part.
Milli,	"	Thousandth part.

* There is surely some mistake here.—Ed.

SYNOPTIC TABLE OF THE METRIC SYSTEM.

Units.

METER—ARE—LITER—GRAM.

10,000 times,	Myria.	
1,000 "	Kilo.	
100 "	Hecto.	
10 "	Deca.	
	Unit.	
		Deci, 10th part.
		Centi, 100th "
		Milli, 1,000th "

Formation of Tables.—The tables of length, land measure, capacity and weight, are readily formed by placing the respective units in the place of unit in the synoptic table:

Length.	Land measure.	Capacity.	Weight.
Myriameter			
Kilometer			Kilogram
Hectometer	Hectar	Hectoliter	Hectogram
Decameter		Decaliter	Decagram
METER.	ARE.	LITER.	GRAM.
Decimeter		Deciliter	Decigram
Centimeter	Centiar	Centiliter	Centigram
Millimeter		Milliliter	Milligram

It may be observed that some of these tables are more extensive than others; according to the nomenclature they should be equal term for term, but practice has determined the limits, as given above.

Relation of Weight and Linear Measure.—According to the metric system, the unit of weight, or the gram, is the weight of a cubic centimeter of water; therefore, one thousand of these, or one kilogram, is the weight of a liter or cubic decimeter of water; one thousand kilograms is the weight of a cubic meter of water. This weight is called a millier, or metric ton.

Metric Units expressed in English Measure.—The following table of values is the result of exceedingly accurate measurements and calculations:

Meter = 39.370790 inches.
Are = 119.60333 square yards.
Liter = 61.02705 cubic inches.
Gram = 15,432.348 grains troy.

Approximate Equivalents.—The following table of approximate equivalents answers very well for calculations in which extreme accuracy is not required:

LENGTH.

64 meters = 70 yards.
25.4 millimeters = 1 inch.

LAND MEASURE.

1 are = 4 perches.
10 ares = 1 rood.
1 hectar = 2½ acres.

LIQUID AND DRY MEASURE.

4½ liters = 1 gallon.
1 hectoliter = 22 gallons.

WEIGHT.

1 kilogram = 22 lb. av.
30 grams = 17 drams av.

LINEAR SQUARE AND CUBIC MEASURE.

10 meters = 11 yards.
10 sq. meters = 12 sq. yards.
10 cub. meters = 13 cub. yards.

How to make a Meter.—Measure off on a slip of wood 3 ft. 3 in. and 3 eighths, divide this length into ten equal parts for decimeters, into 100 equal parts for centimeters, and into 1,000 equal parts for millimeters. This meter is larger than the standard meter by only one part in ten thousand, and may, therefore, be considered as practically accurate.

How to make a Liter.—Take a piece of card-board, and on it construct a square whose side shall be 3 decimeters; subdivide this into 9 square decimeters, cut away the corner squares, and bend up those which remain into a cubical vessel.

How to make a Kilogram.—Balance a liter on a pair of scales with an exact counterpoise; fill the liter with cold water, the additional weight which will be required to restore the balance will be a kilogram. One-thousandth part of this will be a gram.

Retention of the Pound Weight.—In countries which use the metric system, the pound is just as familiar as with ourselves. The half kilogram, or weight of 500 grams, is universally called the pound, and is used in retail transactions. If this weight be called, as it is in Prussia, the new pound, we shall have

10 new pounds = 11 lb. av.

Prices by the pound should, therefore, be increased by 10 per cent if we adopted the metric system. Since 10 meters = 11 yards, the same observation may be made as to prices by the yard.

Consequent Disturbance of Trade.—The prices of nearly every commodity are quoted by the

Hundredweight = 112 lb.
Ton = 2,240 lb.

These weights are only $\frac{1}{20}$th part less than

the corresponding weight used in Continental business—namely,

Centner = 50 kilograms = 110¼ lb.
Ton = 1,000 kilograms = 2,205 lb.

The consequent change in quotations would amount only to 3¾d. in the £1; a change so trifling would cause little or no disturbance in daily business.

THE FORMS OF STEAMSHIPS.

From "Engineering."

At the time when the principal resistance to the motion of vessels through water was believed to be head resistance, or so-called midship section resistance—and the time is not so long ago—nearly all attempts at improvement in form consisted in fining the bow and stern; in diminishing the area of midship section, or rather in providing a given displacement by means of longer, narrower, and shallower ships; and, finally, by introducing Mr. Scott Russell's elegant refinement of wave lines. It was very long ago evident, however, that there was another resistance, viz: that occasioned by the adhesion of the water to the entire wetted surface of the vessel—a resistance now widely and well known as "skin friction." All resistance that was not head and stern resistance was undeniably skin friction, since there were no other known or conceivable resistances to be overcome. But while vessels were propelled by sails only, it was impossible to ascertain the real amount of power expended in driving them, and thus there were no means of ascertaining the relative proportions of the two kinds of resistance to each other.

It was possible, even then, however, to calculate nearly the amount of head resistance for a vessel of given midship section and given angle of bows at any given speed. A flat-fronted or square-ended bow, moving at any given velocity, would, it is true, carry before it a wedge of what may be called dead water, and although the identical water thus carried might be, from time to time, changed by internal currents, generated by fluid friction, this bow of dead water would divide and turn aside the water in front. The case is the same as that to be noticed on the up-stream side of bridge piers, where floating objects are seen to diverge from the general direction of the current, preparatory to their taking one or the other side of the pier, one hundred or even two hundred feet above the pier itself, according to the thickness of the pier and the rapidity of the current. But this does not alter the fact that all the particles of water in front of the bow, supposing them to be at rest, would, if fairly struck, without the diversion caused by the liquid bow of "dead water," be turned aside, at right angles, and with the same velocity as that of the vessel itself. Thus, if the velocity of the vessel were 17½ ft. per second, corresponding to about 10¼ knots an hour, the water would be turned aside with the same velocity of 17½ ft. per second, corresponding to a head of 4.6 ft., and this would occasion a head resistance of 2 lbs. per square inch over the whole midship section of the vessel. If the midship section of a sailing vessel of, say, 36 ft. beam and 18 ft. draught were 500 sq. ft., or 72,000 sq. in., the head resistance would be 144,000 lbs., and at the given speed of 17½ ft. per second, or 1,040 ft. per minute, about 4,540 horse power would be required to overcome the head resistance alone. Supposing, also, that the stern were cut square across, the water falling in behind it would, on striking, be as much below the general level of the sea, and thus there would be a corresponding minus resistance, representing an additional 4,540 horse power, making 9,080 horse power requisite for propulsion, apart from skin friction along the bottom and sides.

This would appear an astonishing measure of resistance at so moderate a speed as 10¼ knots, and for a ship of such moderate midships section, but it is, we believe, correct. As soon, however, as we alter the bows and stern to a wedge form, the head and stern resistances diminish rapidly, in fact in proportion to the square of the sine of the angles to which the bow and stern are beveled. If these formed an angle of but 30° on each side of the keel, the bow and stern thus forming, each, an equilateral triangle, the head and stern resistance would be diminished to one-fourth of what has been estimated for a flat-ended bow and stern, supposed to strike and receive the water at right angles to their faces. If the bow and stern were, each, made twice as long as their width, giving an angle of 1 in 4, or 14° 30′, on either side of the keel, the water would be turned aside and afterwards replaced with but one-fourth the velocity estimated in the case of the square-ended bow and stern, and the power thus required would be but one-sixteenth that first esti-

mated, the power required being always as the square of the velocity of lateral displacement. If the bow and stern were again beveled to an angle of 1 in 6 or 9° 30′, on either side of the keel, the length of bow and stern, respectively, being three times the breadth of beam, the head and stern resistance would be but the one-thirty-sixth part that first estimated; and if an angle of 1 in 8, or 7° 10′, were adopted, the head and stern resistance would fall off to but one-sixty-fourth that estimated for the square-ended bow and stern. It is thus that the head and stern resistances fall so rapidly, as the bows and stern are made finer and finer, and that they soon cease, as Mr. Phipps has shown in his letters, to form the principal resistance. But the resistance implied by a wedge formed bow and stern is a resistance involving the loss of dismissing the water, displaced laterally, with a final velocity sufficient to carry it beyond the mid-body of the hull, whereas it should fall to rest alongside. Every inch of motion of the displaced particles which carries them beyond the ship's beam is a direct loss of power. The fore body, therefore, is eased off by a curve connecting it with the mid-body to diminish the displacing motion, or, rather, to allow the displaced particles to drop of themselves into their proper places by expended momentum. Finally, by hollow water lines at the entrance, the shock, whatever it may be, of instantaneously giving to the displaced water its full lateral velocity is greatly lessened and nearly extinguished, by setting it gradually into a motion like that of a pendulum.

Following the same general principles in forming the stern, we reach a point where the head and stern resistances may be diminished, in some cases, to the one-hundredth part of those attending a flat-fronted bow and a flat-backed stern.

Simple and obvious as this general view of the resistances to the motion of vessels through water may appear, the subject is one which has very seldom, if ever, we think, been popularly treated, and it is one upon which misconceptions may be easily formed from the many apparent difficulties with which a first view surrounds it. If not a spontaneous, it is, at least, a not unwilling acknowledgement to say that some of these misconceptions have been embodied, before now, in our own columns, and Mr. Phipps, who has so well considered the phenomena of the hydraulics of marine propulsion has done good service in suggesting, in his own courteous manner, what was to have been said to the contrary.

If, then, as can be estimated with tolerable exactness, we know the effective engine power actually utilized in driving a steamship, or, in other words, its absolute resistance; and if we then find by calculation that the head and stern resistances form but a small fraction of this resistance, the remainder can be nothing else than skin friction, since, as already observed at the commencement of this article, there are no other known or conceivable resistances beyond those, of course, of wind, tide, and currents, to be overcome. It must be acknowledged that we have long ago passed that stage of improvement in the forms of vessels which left their resistance of form a minimum and their resistance of surface a maximum.

THE NEW WONDERS OF THE WORLD.—Under the heading, "Mirabilia Mundi: VIII, IX et X," "Engineering" says: The Suez Canal, which, not a dozen years ago, was ridiculed here, in engineering England, as a visionary, if not an impractical, scheme, will be virtually completed this year, and Captain Tyler is already reporting to the Board of Trade upon the probable early passage of large ocean steamships direct from Port Said to Suez, on their way from Southampton to Bombay. After passing through the impossible stage, and landing safely on the improbable, this great work was said to be one of £. s. d., as, indeed, most works are, and money, it was said, could not be found to make it. But it will not have cost, according to authoritative statement more than £10,000,000 when completed, a cost not so very far beyond that estimated for the Metropolitan Railway system with its extensions.

The Pacific Railroad, completing the chain of railways 3,300 miles long, from New York to San Francisco, or, in other words, connecting the Atlantic and Pacific oceans, has already been opened this year, although in an incomplete state. But it is something that passenger trains are running daily over 1,721 miles of a continuous new line, made wholly within the last three years, and crossing a mountain range at an elevation higher than that of any other railway in Christendom.

The Mount Cenis Tunnel, as long, 7½

miles, as that part of the Thames, following all the windings, between London Bridge and Putney Bridge, is making rapid progress, and may already count as one of the wonders of the world. Yet even now, when so far advanced towards completion, the great tunnel affords room for the most doubtful speculation, the "Times" Paris correspondent dwelling gloomily upon the prospect of tapping a lake somewhere inside of the mountain!

Wonders never cease, yet the French Atlantic Cable, if successfully laid this year, as presumably it will be, will be no wonder at all, for are there not two cables like it already laid across the bed of the Atlantic?

We now perceive that no one of these great works possessed the fatal defect of impossibility; indeed, they almost appear as if, from the first, they were conspicuously practicable and simple in their character, requiring, of course, time and money, and, perhaps, just a *little* skill. None of them happen to be the works of English engineers, so we can afford to be somewhat complaisant — don't let us say patronizing.

But there is a work in prospect which English genius may yet achieve — and it will assuredly be by English genius if achieved at all—which, not in mere length, nor in geometrical magnitude, but in the stretch which it might impose upon the highest resources of the combined skill, patience, and courage which a whole institute of engineers ever possessed, will surpass any one of the great modern wonders of the world which we have enumerated. That work is the Channel Tunnel. It is a work depending upon a great engineering IF, and a great financial IF, and possibly, although we trust not, upon a great political IF. Of the three *ifs*, possibly the engineering *if* is the greatest, although we would wish to believe otherwise — indeed, there *are* reasons for believing otherwise. In that submarine valley between Dover and Cape Grisnez, twenty miles across, and 200 ft. deep, can the chalk be depended upon as continuous? Mr. Hawkshaw's borings have probably already well-nigh settled that. A single deep fissure, filled with sand, would pour in a torrent, under a pressure, in mid-channel, of at least 100 lbs. per square inch, sweeping everything beneath it. One is tempted into a wide field of geological speculation upon the subject, but it may be dismissed for the present with this hasty suggestion.

IRON SHIPBUILDING.

Abstract of a paper before the London Association of Foremen Engineers, by Mr. JAMES RAE, and of the discussion, by Mr. E. J. REED.

The frequent disasters to iron ships must be in most cases attributed to defective construction. Iron ships, as a rule, were built with frames of that metal, the outer skin being formed of plates of iron and the inner one of timber planking. This latter served as a floor for the reception of the cargo, but it was no safeguard in the event of the outer skin being penetrated. Great stress had sometimes been put upon the efficiency of bulkheads. Practically they were really of little value. Steamships were usually furnished with four or five. These were supposed to be water-tight. Too frequently it was found, in the fell moment of peril, that they were nothing of the kind, and that after a collision it might be said of the vessel that she contained "water, water everywhere," whilst the pumps were incapable of discharging it. Bulkheads were, in ninety-nine cases out of the hundred, illusory and deceptive protectors of iron ships. Vessels of this kind, as now constructed, were calculated well enough for ordinary service under favorable circumstances, but were totally unfitted to contend against the extraordinary accidents which often befell them at sea. It was quite true that the past twelve years had witnessed great improvements in the construction of iron vessels, both as regarded the quality of the material used and in its mode of application. The author of the paper introduced at this point some startling facts which had come under his own notice when engaged as manager for a large shipbuilding company, and which demonstrated very forcibly the haphazard modes of construction commonly practiced not many years since. Mr. Rae also took some credit to himself for remedying the evils to which he referred, and especially considered himself entitled to commendation for having been the first to introduce the plate-planing machine into the shipbuilding yard. This apparatus was now almost universally employed instead of, or as supplementary to, the shearing machine, and Lloyd's rules distinctly specify that all "butts" shall be planed. The economy and the excellence of iron shipbuilding had been enhanced in a remarkable degree by the use of the planing machine.

The author next addressed himself to the question of internal defects in the construc-

tion of iron ships, and pointed out more particularly the weakness which was formerly observable in regard to the head and stern. In 1858 he decided to commence an improved system of connecting the stem and stern of vessels entrusted to his building with the keelson. The keelson plate was, in reality, carried up the stem and stern to a considerable height, and the solidity of the vessel was thus increased three-fold. The plan was patented, but, by a legal quibble, the inventor derived no advantage in a pecuniary sense, but, on the contrary, sustained a heavy loss in the shape of costs. The Admiralty had adopted the scheme without recognizing its promoter, and it was now public property, for all who were engaged in iron shipbuilding know its value and used it as freely as the Government.

Mr. Rae then proceeded to say that all iron vessels ought to be built with an internal as well as an external iron skin, the latter of course being of the greater thickness. Both skins should be made perfectly watertight. Between the inner and the outer skins a series of bulkheads, say 9 ft. apart, and extending from gunwale to gunwale, should be affixed. The spaces between the bulkheads should be filled in with asphalte, so as to prevent water passing from one space to another. Such an arrangement would add but little to the original cost of the ship, whilst it would increase her strength fully fifty per cent.

Mr. E. J. Reed, Chief Constructor of the Navy, commenced the discussion which followed the paper, and in doing so said that he agreed with its author as to the generally faulty construction of iron ships as built some few years since. Even now he thought that legislation might be beneficially employed in regard to the construction of iron ships for commercial purposes. He considered that the Admiralty had not acted unfairly towards the reader of the paper. That gentleman had no doubt discovered the weak points to which he had referred in regard to the stems and sterns of the older iron ships, but so had many others, and it was hardly to be expected that so self-evident an improvement could come under the prohibitory provisions of letters-patent.

As to the double-skinned vessel with asphalte "filling" between the bulkheads. he had little faith in it. The ship in such case would be permanently loaded very much to her detriment, whilst the contingent advantage was problematical. He wished also to say that in every instance where bulkheads were used in the royal navy, their water-tight qualities were tested by hydraulic pressure.

EXPLOSIVE AGENTS.

Abstract of a paper read before the Royal Society by F. A. ABEL, F. R. S.

The degree of rapidity with which an explosive substance undergoes metamorphosis, as also the nature and results of such change, are, in the greater number of instances, susceptible of several modifications by variation of the circumstances under which the conditions essential to chemical change are fulfilled.

Excellent illustrations of the modes by which such modifications may be brought about are furnished by gun-cotton, which may be made to burn very slowly, almost without flame, to inflame with great rapidity but without development of great explosive force, or to exercise a violent destructive action, according as the mode of applying heat, the circumstances attending such application of heat, and the mechanical condition of the explosive agent, are modified.* The character of explosion and the mechanical force developed, within given periods, by the metamorphosis of explosive mixtures, such as gunpowder, is similarly subject to modifications; and even the most violent explosive compounds known (the mercuric and silver fulminates, and the chloride and iodide of nitrogen) behave in very different ways under the operation of heat or other disturbing influences, according to the circumstances which attend the metamorphosis of the explosive agent (*e. g.*, the position of the source of heat with reference to the mass of the substance to be exploded, or the extent of initial resistance opposed to the escape of the products of explosion).

Some new and striking illustrations have been obtained of the susceptibility to modification in explosive action possessed by these substances.

The product of the action of nitric acid upon glycerine, known as nitroglycerine or glonoine, which bears some resemblance to chloride of nitrogen in its power of sudden explosion, requires the fulfillment of special conditions for the development of its explosive force. Its explosion by the simple ap-

* Proceedings of the Royal Society, vol. xiii., pp. 205 *et seq.*

plication of heat can only be accomplished if the source of heat be applied, for a protracted period, in such a way that chemical decomposition is established in some portion of the mass, and is favored by the continued application of heat to that part. Under these circumstances the chemical change proceeds with very rapidly accelerating violence, and the sudden transformation into gaseous products of the heated portion eventually results, a transformation which is instantly communicated throughout the mass of nitroglycerine, so that confinement of the substance is not necessary to develop its full explosive force. This result can be obtained more expeditiously and with greater certainty by exposing the substance to the concussive action of a detonation produced by the ignition of a small quantity of fulminating powder, closely confined and placed in contact with, or proximity to, the nitroglycerine.

The development of the violent explosive action of nitroglycerine, freely exposed to air, through the agency of a detonation, was regarded until recently as a peculiarity of that substance; it is now demonstrated that gun-cotton and other explosive compounds and mixtures do not necessarily require confinement for the full development of their explosive force, but that this result is attainable (and very readily in some instances, especially in the case of gun-cotton) by means similar to those applied in the case of nitroglycerine.

The manner in which a detonation operates in determining the violent explosion of gun-cotton, nitroglycerine, etc., has been made the subject of careful investigation. It is demonstrated experimentally that the result cannot be ascribed to the direct operation of the heat developed by the chemical changes of the charge of detonating material used as the exploding agent. An experimental comparison of the mechanical force exerted by different explosive compounds, and by the same compound employed in different ways, has shown that the remarkable power possessed by the explosion of small quantities of certain bodies (the mercuric- and silver-fulminates) to accomplish the detonation of gun-cotton, while comparatively very large quantities of other highly explosive agents are incapable of producing that result, is generally accounted for satisfactorily by the difference in the amount of force suddenly brought to bear in the different instances upon some portion of the mass operated upon. Most generally, therefore, the degree of facility with which the detonation of a substance will develop similar change in a neighboring explosive substance, may be regarded as proportionate to the amount of force developed within the shortest period of time by that detonation, the latter being, in fact, analogous in its operation to that of a blow from a hammer, or of the impact of a projectile.

Several remarkable results of an exceptional character have been obtained, which indicate that the development of explosive force under the circumstances referred to is not always simple, ascribable to the sudden operation of mechanical force. These were especially observed in the course of a comparison of the conditions essential to the detonation of gun-cotton and of nitroglycerine by means of particular explosive agents (chloride of nitrogen, etc.), as well as in an examination into the effects produced upon each other by the detonation of those two substances.

The explanation offered of these exceptional results is to the effect that the vibrations attendant upon a particular explosion, if synchronous with those which would result from the explosion of a neighboring substance in a state of high chemical tension, will by their tendency to develop those vibrations, either determine the explosion of that substance, or at any rate greatly aid the disturbing effect of mechanical force suddenly applied, while, in the instance of another explosion, which develops vibratory impulses of different character, the mechanical force applied through its agency has to operate with little or no aid; greater force, or a more powerful detonation, being therefore required in the latter instance to accomplish the same result.

Instances of the apparently simultaneous explosion of numerous distinct and even somewhat widely separated masses of explosive substances (such as simultaneous explosions in several distinct buildings at powder-mills) do not unfrequently occur, in which the generation of a disruptive impulse by the first or initiative explosion, which is communicated with extreme rapidity to contiguous masses of the same nature, appears much more likely to be the operating cause, than that such simultaneous explosions should be brought about by the direct operation of heat and mechanical force.

A practical examination has been instituted into the influence which the explosion of

gun-cotton, through the agency of a detonation, exercises upon the nature of its metamorphosis, upon the character and effects of its explosion, and upon the uses to which gun-cotton is susceptible of application.

THE VENTILATION AND TRAPPING OF DRAINS.

From a paper before the Society of Arts, by JAMES LOVEGROVE, Esq., Assoc. Inst. C. E.

The subject embraces the ventilation of drains, the trapping of gullies, and the various modes adopted for preventing sewer air passing out of gully and drain inlets.

The author of this paper has been led to attach considerable importance to the subject of drain ventilation, in consequence of having, in many instances, observed in houses where sanitary works had been carried out, a larger amount of effluvia after the execution of drainage works than existed before. He therefore purposes, in order that the subject may be fully and fairly put before the Society, to refer to the various means by which sewage matter has hitherto been conveyed from houses; to notice the effect upon the air in drains of discharging sewage matter into them; to suggest a new mode of ventilation; and also to consider the means usually employed to prevent the escape of sewer air through gully and drain inlets.

Some twenty or thirty years ago, public sewers were permitted to receive waste and refuse waters only, the closet drainage being carried into cesspools. The wash-house sink discharged the waste on to the surface of the back yard, by a pipe which passed through a hole in the external wall; the other waste water flowed along an uncovered drain beneath the floor of the house, and thence over the surface of the footway into the side channel of the street, so that, at all times during the day, a dirty stream of sewage might have been seen flowing along the channel. The exhalations from the uncovered cesspool, from the soaked and saturated materials of the uncovered drain, and from the exposed stream of sewage in the street, were most offensive. A covered sewer along such a street was next introduced. Gradually, covered drains were constructed beneath the houses, and connected with the new sewer, but with untrapped inlets, and untrapped gullies were also formed in the street channels to carry off the surface water. Thousands of cesspools were next connected with the sewer by overflow drains, and these allowed the effluvia therefrom to escape through the inlet opening, and caused a nuisance as great, or nearly so, as existed under the original state of things.

The next step was that of abolishing cesspools, and fixing pan-inlets, in direct connection with the drain leading into the sewer. The result was that, although the nuisance arising from the cesspools had been removed, the effluvium escaping through the untrapped drains and gullies was increased tenfold. The cesspool had been a long-standing abomination before the water-closet was thought of as the readiest way of getting rid of the nuisance. But this remedy, though so universally adopted, should be regarded by all as one of a palliative character only, as it not only causes the pollution of our rivers, but requires more than half the water supply to keep the closets clean. It is, however, hoped that modes of collecting the excreta and the most valuable portion of town sewage, without destroying their valuable properties, will, ere long, be introduced, and that the sewers will simply be put to their original use of receiving waste and refuse waters only. The dry earth closet may be a step in the right direction, and should receive a fair trial, in spite of the few difficulties which have to be met with at the outset.

In inquiring into the causes of air currents, either from or within drains, it is suggested that the variable flow of sewage has a powerful influence on the air within the drain, whilst that produced by rainfall has still greater, and the variations of tempera-

No. of observations.	No. and sizes of drains.					Velocity in feet in five minutes.		Ingress or egress.	Remarks.
	18 inches.	15 inches.	12 inches.	9 inches.	6 inches.	Minimum.	Maximum.		
170	....	....	....	27	....	50	200	ingress.	
	....	....	....	1	....	....	1,000	ingress.	
	....	....	....	1	....	....	1,650	ingress.	
	....	....	....	14	....	50	100	egress.	
	....	....	....	1	....	....	250	egress.	
	....	....	....	1	....	....	400	egress.	
	....	....	....	125	....	....	....	.....	quiet.
48	....	....	....	....	11	50	100	ingress.	
	....	....	....	....	8	50	1,600	egress.	
	....	....	....	....	29	....	....	.....	quiet.
12	....	....	2	....	....	50	50	ingress.	
	....	....	2	....	....	100	100	egress.	
	....	....	8	....	....	....	....	.....	quiet.
8	....	2	....	....	....	50	100	ingress.	
	....	1	....	....	....	....	150	egress.	
	....	5	....	....	....	....	....	.....	quiet.

ture are another cause of displacement and renewal of drain air. The table shows a series of observations taken at the outlets of drains, at the points of connection with the sewer. They were taken by Biram's anenometer, and the results show that up and down currents of air are constantly passing to and fro. Whenever an up-current issues through a drain opening, it must be manifest that some of the inlets of such drains are untrapped, and, therefore, sewer air must be escaping through such untrapped inlets, to the danger of those who reside in the house. In the construction of gully inlets there are two principles which should be strictly observed, viz.:

1. To prevent, as far as practicable, the entry of road detritus into the sewer.

2. To prevent the escape of sewer air through the inlet.

Various methods have been adopted. Twenty different forms of traps in general use are all dependent on being constantly charged with water, and may be easily proved to be inefficient for the purposes for which they were designed, and for these reasons should be condemned. The sewer air is separated from the atmosphere by the ¼-inch of water, or at the most an inch, and a few days' dry weather is sufficient to untrap most of the gully inlets, as the water quickly evaporates to below the siphon-dip. This evaporation is aided, in many cases, by the absorbing power of the materials with which the inlets are constructed, and also by matters falling into them. These gully traps are often fixed in a narrow street close to the open doors and windows of the houses, and are, it is feared, in many instances, the cause of much ill-health. Traps constructed on this principle have been observed by the author in an untrapped condition, in Derby, Leicester, Windsor, and other places. Another form of trap, largely used for street gullies in the metropolis, is known as the shackle-flap, sometimes fixed at the end of a 12-inch or 15-inch length of pipe, and sometimes in the form of a square block. The flap and its seating form two plain metallic surfaces, and it therefore does not admit of partial separation of the surfaces, as the smallest possible opening made by the overflowing water separates the surface throughout, so that, while the water is flowing through the lower part of the valve, the sewer air escapes through the upper part. The flaps are sometimes fixed at the point of connection with the sewer; their action has been tested where thus fixed. A lighted candle has been held at the sides of the flap during the passage of water through the gully, and a strong current of sewer air was found passing through the upper part of the flap during the period of flow. The system adopted by the author is constructed on the two principles hereinbefore mentioned, and forms a combination of the siphon-dip and shackle-flap. It is made in two forms; one form having the appearance of a bent tube, nearly semicircular in shape, and inserted so that one end of the tube, called the siphon-dip, dips into the cesspit beneath the gully grating, and the other discharges into the outlet, the valve-flap being fixed within the tube. The other form is that of an oblong block of stoneware, having a 6-inch opening formed diagonally through it, so that the valve on the outlet side is from 1 to 2 inches higher than the opening in the block on the cesspit side, both on the same principle, but in different form. The siphon-dip prevents the escape of sewer air through the upper part of the shackle-flap during the period of flow, and the flap resists the upward pressure of the sewer air, thus effectually sealing the inlet. The pressure of the sewer air within assists in closing the flap, whilst the pressure on the inner face by the atmosphere opens the flap, and allows a refreshing current of air to pass into the sewer. This current is generally so strong as almost to blow out the light when placed near to the flap, and should be maintained, but so as not to admit of the escape of sewer air.*

The escape of sewer air into houses gave rise to the adoption of various forms of traps. For drain inlets, I believe the first trap used was the dip-trap—a brick cesspit formed usually about 18 in. square and 6 in. below the drain, the inlet on one side being separated from the outlet on the other side by a division of stone, slate, or iron, made to dip about an inch into the water of the drain. The well-known common siphon was an improvement on the old dip-trap for the main line of drain, and in a ventilated drain these are efficient, inasmuch as, from one source or another, they are always charged with water. This form of trap is used by the author in combination with an air tube and valve, the latter acting as a ventilator. The principle of the water-dip has been put into

* Gully and drain traps on this system are made by Mr. Jennings, of Lambeth.

various forms of drain inlets, but they all are dependent on a very small thickness of water for their action, and are quickly untrapped by evaporation, and then the result is precisely the same as if there were no trap at all. The common bell-trap is more frequently met with than any other form of trap. The mere film of water at the rim of the inverted bell is supposed to prevent sewer air passing through, but, generally speaking, when the sewers are in the most foul condition, that is, in the summer season, the required film of water is not in the trap, and it then forms a sewer ventilator. A piece of house-flannel, cotton, or other similar matter entering the bell-trap inlets, will often hang partly in the bell basin and partly out, and, by siphonic action, quickly draw off the water to a level below the rim of the inverted bell. These traps exist in almost every house, and are the cause of a large amount of illness. These remarks are applicable to all the forms of trap dependent on a constant film of water for their action, which are, consequently, not reliable.

[The paper then gives a number of examples of drains becoming untrapped in hospitals, residences, &c.; among others, the following:]

In a public hospital, near Portman-square, a brick drain in direct connection with the sewer passed sewer-air inwards so strongly as to blow out the flame of a candle. This drain continued through the building, and received in its way the raised sink-inlets, also the drainage from the lavatories, sinks, and water-closets on the upper floor. In this case, when water was passed from one or other of the inlets, it caused the contained air first to press against the water in the inlet water-traps, and, on reaction, to draw off sufficient water to untrap the inlet. Thus, through one or other of the inlets, air was generally escaping into the house.

In further considering the action of drain-traps, we will refer to a drain trapped at its outlet with a shackle-flap, and the several inlets trapped with the ordinary water-traps. When water is poured into a drain thus constructed, the result depends in a measure on the relative weight of the shackle-flap at the outlet as compared with the resisting power of the water-traps. If the flap be lighter, the pressure exerted on the air contained in the drain by the in-flowing water, will act on the inner face of the flap, force it open, and discharge a bulk of air into the sewer. Then, while the water is passing through the lower part of the flap, the sewer air will enter by the upper part, and thus the drain will be filled with sewer air, even while the water-traps are full. If one of the inlet-traps were unsealed, the air would pass through the unsealed trap instead of into the sewer. If the shackle-flap be the stronger resistant of pressure, the water poured into the drain will act on the surface of the water in the weakest of the water-traps, and impart to it a rocking motion, causing part of it to flow out of its basin. The atmosphere will also press on it, in the endeavor to take the place of the out-flowing water, and thus untrap the inlet, so as to allow the sewer air to enter the upper part of the shackle-flap during the period of flow. Then, if the outlet-trap be a common siphon, or the old form of dip-trap (which in principle are both precisely the same), then the sewer air will be entirely shut off, but the force of displacement of the contained drain air will most likely enter the house through the kitchen sink, as the air of the drains must escape somewhere, under the pressure of in-flowing water. In such a drain, the more water there is thrown into it, the more effluvia will escape. The slimy coating also of the interior of a long length of drain, is of itself sufficient to contaminate the contained air, no matter what fall the drain may have. In the methods just described, the one idea has been an unsuccessful endeavor to stop the opening from which the smell escaped, without inquiring if this or that opening is stopped, what will become of the foul air, what new state of things is produced, and what are the influences actually at work. Certain it is, that the more generally adopted of trapping inlet-drains favors the escape of sewer air into the houses.

Now, all that has been stated suggests that, in the trapping of drains, there must be provided—

1st. A ready and proper outlet for the escape of the drain-air when under pressure.

2nd. A means of supplying air to the drain, to follow the out-flowing water.

3rd. Such a construction of the inlet-traps as will effectually prevent the escape of drain-air.

The way in which these three principles may be applied is as follows: The outlet-trap is fixed at or near the point where the drain is connected with the sewer, and is made in one piece, with a siphon-dip, to shut off the sewer air, and an air-exit tube pass-

ing over the siphon-dip. Then, at the mouth of the air-tube a light metal air-valve is placed, so as to open outwards from the tube into the sewer on receiving a light pressure from within. Thus, when water is discharged into the drain, or a decided difference of temperature exists, the pressure of the air is exerted on the inner face of the valve, which then opens, and allows the drain-air to pass into the sewer. The siphon-dip, without the shackle-flap, is admissible at the outlet of a ventilated drain, as it is always charged with water. Then, at the several inlets are fixed valves to work freely, with siphon-dips behind them, excepting the water-closets and scullery-sinks. The valve shuts off the drain-air, whether there is water in the trap or not, and the siphon-dip prevents the escape of drain-air, during the period of flow, through the upper part of the valve. No amount of pressure from within the drain, or atmospheric influence from without, can affect the efficiency of these traps. Next, in any part of the drain (near the extremity is best) is placed an air-supply post, containing a light air-supply valve, which opens inward to the drain on a light pressure, so that when the water is emptied into the drain (having first displaced air through the outlet air-valve) flows out of the drain, it is followed by a supply of air through the air-supply port. The more water discharged into the drain, the more frequent will be the removal of air. In the application of this principle to a drain having inlets at a considerable elevation, in lieu of the air-escape at the outlet traps, an air tube is carried from the highest point of the drain to a height as far as possible from the windows and the influence of chimney down-draught. The inlets are secured by the same mode as that just previously described, a common siphon at the outlet, and the air-supply valve fixed near the outlet of the drain. By this mode a current of air is obtained from the lower part, passing through the drain, and discharging above the roof. In many instances air supply is obtained freely through the valve-sink inlets.

In the case of a house-drain connecting into a pipe-sewer, in order to obtain a ready access to the air-valve and siphon-dip, the air-tube is continued on to the surface side of the dip, where it receives a box, containing the air-exit valve. The air-tube thence continues down to the outlet side of the dip, and the air is discharged into the sewer.

The form of sink made for a garden-sink is adapted for yards, areas, stables, gardens, cellars, &c. A cheaper one for cottages is made in stoneware, with spigot-ends at the valve-mouth to fit the socket of an ordinary drain-pipe, and finished with a socket-flange at the top, to receive a perforated iron or stoneware plate; the workman laying the drain can thus complete his work without sending for the bricklayer, laborer, bricks, and cement, to form the receiver usually constructed beneath a bell-trap or 5-hole sink.

The form used for stables and large yard surfaces is made wholly of iron. An iron nozzle-piece is attached to the outlet, forming a spigot-piece, and is made to fit into an ordinary socket-pipe.

Scullery sinks are very difficult things to secure, because of the rapid accumulation of grease. Valves are inadmissible, except in the form of a gully-trap and receiver, which are found to be safe and effectual. The pipe from the sink should, in that case, be continued so as to dip into the receiver. In small scullery-sinks a deep form of garden-sink, without the valve, would be much cheaper, and is found to be effectual. The valve is also unsuitable for a closet-inlet, as the paper clogs the valve, and the siphon-trap of the closet is never dry, and is not subject to variation in a ventilated drain.

A few words on the subject of water-closets. It is as well to state some objections to the form of closet in general use. The well-known valve-closet, formed by a valve about 2 in. in diameter, closing at the lower part of the pan, is liable to leakage at the valve, and, when this occurs, the corrupted air contained in the iron chamber beneath escapes into the house.

A large number of copper and zinc pan-closets are in use. We have first the stoneware basin, then a swing pan of copper and zinc, then a large iron pan beneath these, and this iron pan has a surface of metal coated with foul matter equal to $4\frac{3}{4}$ ft., and in contact with the external air. The common closet-pan contains one-third of a foot super., but the most cleanly closet I have met with is one made by Mr. Jennings, which was in use at the last Great Exhibition, exposing a surface of $1\frac{1}{8}$ ft. only in contact with the soil, giving off the least amount of effluvia. A common stoneware pan is preferable by far, in the matter of cleanliness, to many of those costly contrivances that are in daily use.

In conclusion, the author hoped that the importance of this subject would be an excuse for the length of this paper.

COAL BURNING ENGINES IN ENGLAND.

In a series of articles on Railway Economy in "Herepath's Railway Journal," a history of the devices for preventing smoke and burning coal economically, is given, and the present practice is described.

The means that have been chiefly employed are extended fire grate surface, so as to have a thinner fire and afford a larger area for the passage of the air; and stepping or inclining the grate at a considerable angle, so that the coal being introduced close to the fire door, may gradually travel forwards as it parts with its gases and becomes incandescent, and thus ignite the gases that pass over it from the fresh fuel; making a double fire box with the same object; the application of a combustion chamber with or without fire-bricks, which become heated and ignite the gaseous products as they pass through or over them; and combined with these, various plans for admitting the requisite supply of air above the fuel, either by deflecting it as it passes through the fire door, or by introducing it through tubes or air passages.

Gray and Chanter in 1847 divided the fire box into two parts and admitted air above the fire. Dewrance improved upon this idea in 1845, and McConnell again in 1853, both these experimenters using the combustion chamber. The trouble, up to this time, was to ignite the gases distilled from the coal. In 1855 this was *perfectly* accomplished by Beattie,* but at the expense of maintaining and transporting some tons of fire-bricks. Cudworth's inclined grate came into some favor about this time. In 1856 Messrs. Dubs and Douglas applied a deflecting feather proceeding from the back of the fire-box towards the tube plate, to cause the gaseous products of the coal to descend on the incandescent fuel and thus become ignited, and Mr. Dubs, in connection with Mr. Evans, in 1857 added to this a movable inclined grate, which could be raised or lowered at will, for the proper management of the fire.

In 1857 Mr. Yarrow introduced a flat arch of fire-brick in the interior of the ordinary fire-box, placed at a considerable inclination, the lower side commencing just under the lowest row of tubes, projecting upwards until within eight or ten inches of the roof of the fire-box; tubes were also provided in the tube plate under the arch as well as in the fire-door for the admission of air.

The gases would thus be deflected, and have to pass round this brick arch, being at the same time heated and supplied with a fresh dose of oxygen from the air rushing in through the tubes. Considering that this was simply a modification of the fire-box originally designed to burn coke, the results were very satisfactory. A very similar plan was introduced by Mr. Jenkins on the Lancashire and Yorkshire railway, but in place of a fire-brick arch he employed a curved deflector of cast iron similarly placed, but perforated near its outer edge with numerous holes. He also employed air tubes at the front of the fire-box under the fire-door, as well as at the back under the tubes.

In 1857 Mr. D. K. Clark devised a system of forcing air into the fire-box through air tubes placed at the sides by fine steam jets directed from the outside and passing through the air tubes, which acting in a similar way to the blast pipe of the engine, caused currents of air to rush into the fire-box with great force. The orifice of the jets is but $\frac{1}{16}$ inch in diameter, the air tubes $\frac{1}{2}$ in. This simple arrangement was found to completely prevent smoke without any further appliance. It has been at work satisfactorily on several lines, and has been adopted on all the locomotive stock on the Great North of Scotland railway. Whether the steam which is introduced into the fire-box performs any office beyond the mere mechanical one of drawing the air in along with it, in producing any new chemical combination which would facilitate the combustion of the volatile gases, does not seem to have been investigated. It would, however, to some extent warm the air, and perhaps make good the loss from the use of the steam in this manner; and it is supposed that the steam has some power to precipitate the carbonaceous particles which remain unconsumed; at any rate the plan seems to be very economical. There is one advantage possessed by this plan over most others, viz., that by the use of these steam jets when the engine is in a station the smoke can be prevented, as they act in a more direct manner than a jet in the chimney.

In 1858 Mr. Wilson introduced a system

* See "European Railways," Colburn and Holley, for details.

of air tubes which extended from the fire-box right under the boiler to outside the front of the smoke-box. This arrangement would partly effect the object of Mr. Clark's steam jets when the engine was running, since the air would then be driven through these tubes into the fire-box with considerable force. Mr. Ramsbotham also about the same time provided two small doors in front of the fire-box, under the barrel of the boiler, with regulating valves for the admission of air above the fuel, and just above these openings he placed an arched fire-brick deflector, something similar to that of Mr. Yarrow.

Messrs. Lee and Jaques also introduced a somewhat similar arrangement as regards the projecting fire-brick arch, but they combined with this a deflector fixed to the top of the fire-door. This deflector projected into the fire-box sloping downwards, the door itself being underhung and provided with a valve for the admission of air, the opening and closing of which was regulated by a sector. The air being drawn in through the valve in the fire-door, would by means of the deflector be directed downwards, and mix with the gases, and their combustion be effected by impinging on the incandescent fuel, and the brick arch fixed against the plate.† About the same time Mr. Frodsham employed a deflecting plate over the fire-door, but the brick-arch was omitted, and in place thereof two steam jets were introduced, one on each side, into the front part of the fire-box, impinging downwards upon the fuel. Mr. Douglas employed a deflector with the same object, but he combined with it an inclined fire grate of larger area, which involved a longer fire-box, and of course necessitated an alteration in the boiler or the construction of new engines.

THE LOCOMOTIVE OF THE FUTURE.

From "Engineering."

It would be difficult for the most enthusiastic engineering futurist, if at all practical, to point out the direction in which any radical improvement in the locomotive engine is to be sought. As long as the resistances opposed to the motion of trains are what they are, and as long as the present rates of speed are maintained, the amount of locomotive power to be provided cannot be lessened. There is not the slightest chance that any other agent than steam will be employed, in our generation at least, to produce this power. Compressed air locomotives, hot air locomotives, vapor of alcohol locomotives, and electro-magnetic locomotives have all been tried, and they have failed for perfectly obvious reasons—reasons which should have been foreseen by any one possessing the least knowledge of the motive agencies thus called into play. Steam, then, being our only resource, it can be generated only by the combustion of fuel, and this fuel must obviously be the cheapest available. With us, the cheapest fuel is coal. We can none of us see the way to anything cheaper. Petroleum may be burnt easily enough—its use is entirely practicable, but it is too dear. Even were it cheaper than coal, its use would involve no important constructive modifications of the locomotive boiler, and none whatever in the working machinery.

And what can be simpler than the locomotive boiler as it is. A large amount of heating surface *must* be provided, and how could it be better provided? There are few who would not desire to welcome improvements were they possible, but it will prove no easy task to improve upon the principles, or the construction, of Neville's multitubular boiler of 1826, as successively improved in detail by so many locomotive engineers since George Stephenson first brought it into practical work. The locomotive boiler has been made in almost every possible form. There have been twin barrels, double fire-boxes, round fire-boxes, combustion chambers, mid-feathers, return tubes, water tubes, water grates—indeed, every imaginable modification of the original structure to which all successful practice has again returned.

We have no doubt that steel will yet take an important part in locomotive boiler construction, as it has already done in that of fixed boilers. The Bolton Steel and Iron Company appear at last to have produced Bessemer steel boiler plates which can be thoroughly depended upon in large quantities, and there are fire-boxes of a somewhat kindred material—Howell's homogeneous metal—which have perfectly withstood nine years' use on the Scottish Central Railway. In all this, however, there is no new principle, and the most that can be hoped from steel, is somewhat greater economy in repairs, and the possibility of working higher pressures of steam, should it prove desirable to do so.

† This deflector in front of the fire-door, generally without the bricks, is now much employed in England with quite good results.—Ed. V. N. M.

In the motive machinery of the locomotive, beginning with the regulator and ending with the driving wheels, no improvements beyond those of mechanical detail appear to be possible. No possible application of the principle of the rotary engine holds out the least hope.

As for the rest, the locomotive engine is a carriage merely. So much total weight, divided by so much permissible weight per wheel, and we have the necessary number of wheels, to be coupled or not, according to the requisite adhesion.

It is only as a carriage that we see much room for improving the locomotive. It does appear anomalous that with from one hundred to two hundred wheels beneath a train, none of them loaded beyond 3 or 3½ tons, a permanent way of twice the strength otherwise necessary should be required to carry 7 tons each on a pair of driving wheels. It is equally inconsistent that with wheel bases of from 8 to 10 ft. under the wagons and carriages, from 15 to 18 ft. should be necessary for the engine. Were the maximum weight per wheel not more than 4 tons, and the maximum wheel base in any one unalterable rectangle no more than 10 ft., it is almost beyond dispute that a very considerable economy would be effected in the maintenance of the permanent way.

PATENTS.

The abolition of protection for inventions has frequently been discussed in England, but the late advocacy of such a step in parliament, and by persons of importance and influence, has created an unusual excitement among the classes most interested, which has found copious expression in the London scientific press. For a government to broadly declare that the rights of property in inventions should cease, would be as foolish and suicidal as to broadly declare that there should be no property except in material, tangible things—that the intangible results of one man's mental labor should be the property of all men. Under such a law few inventions would be made, simply because they could not be protected. Successful inventions, that benefit mankind and advance civilization, are almost invariably the fruit of costly experiment. The first ideas of the greatest inventors are crude. Watt, Bessemer, Morse, Goodyear, Ransome, Howe, Corliss, Roberts, Siemens, Ericsson—none of these men perfected their works at the start. Their success is due vastly more to their persevering warfare against "practical difficulties"—to the pluck and business capacity of themselves and their partners, than to their original discovery or combination of certain materials and forces. Is it reasonable to suppose that Bessemer, for instance, would have worked for five years against all manner of difficulties, and at a cost to himself and associates, of many thousands of pounds, to make the pneumatic process a success, if the sole fruits of his brain and fortune were to be then snatched out of his hand, without one penny of compensation? Yet, just that labor and fortune had to be risked by somebody, or the pneumatic process would have been perfectly impracticable and useless. Inventions cannot be protected by being kept secret—there is no use in arguing this point—and if they were kept secret, how far would the public be benefited by them? If the patent laws are abolished, all the men who have the capacity and means to *work out* great improvements, will have to do so at their own expense, for the benefit of their rivals in business, and without hope or right of reward. When business men present one another with checks and pig iron and cotton and farms and machinery, inventors may be expected to work without protection. In short, if the patent laws are abolished, the stimulus to working out inventions and making crude ideas practicable, will be taken away—there will be no farther reason why men should invent, and they will stop inventing. They may, indeed, start ideas, generally undeveloped, but they will not and cannot, on any other ground than general philanthropy, undertake the cost of making their ideas practical and useful, and this is what the law recognizes as the subject of a patent.

Only two apparently reasonable grounds of objection to property in inventions have been put forward. The first is, that only one in a hundred inventions is useful. Well—is the public injured because a man obtains a patent for a useless invention, any more than it would be if he spent the same money on a useless building? In the former case he neither creates *nor destroys* any value. But it will be said that the inventor of a useless machine "ties up" combinations and parts which another man could, if they were free, make useful. Nothing could be more at fault than such a statement. The patent law contemplates a machine that will perform the functions claimed. If it

will not, the patent is invalid, and the parts and combinations *are* free. If it will, and the functions are desirable, then the invention is not useless, and the inventor is entitled to just what he invented—no more. If another inventor makes an addition that enlarges or betters the functions, or cheapens the operation, he is entitled to just that improvement—nothing more—and the parts and combinations that are tied up by the first patent, are no more unfairly tied up than the first inventor's house and shop are—they do not belong to the second inventor—he found them the possessions of another.

"But says the objector—"Many patents claim more than they can accomplish—the *untying* of parts and combinations thus involved is a tedious and costly process of law." This is true, but the embarrassment is the inventor's, not the public's. If inventors are willing to go to such cost to establish their claims, the public is not only uninjured by the process, but it is largely benefited by the result. Suppose that property in patents were unlawful, so that inventors could not test the validity of their works in the courts, and would have no inducement to do so if they could—how much better off would the public be then? They would not, indeed, have to pay any royalty to either contestant, nor would there be any improvement to use. They could reap by hand and go on foot at ten times the cost of machinery, and save a small fraction of their loss by not paying royalty.

The main argument against the patent laws is, that where the public possesses, in common, all the elements of the knowledge out of which an invention may proceed, it is unjust that he who happens to have a week's or a month's start over his fellows in arriving at an important practical application of that knowledge—an application which, it is assumed, scores of others are seeking, and which, it is furthermore assumed, some of them would, in a short time, have certainly attained—it is unjust, the argument repeats, that the first one who finds out what others *might* have found out, should be permitted to block up the road against them. In answer to this, "Engineering" says: "In other words, although the world had waited six thousand years or so for a given invention, it was certain that a dozen or more inventors were as near to attaining it at a given time as would a dozen competing horses be near to the winning post at Epsom within five seconds of the finish. All this is merely begging the question, if it be not, indeed, a mere display of idle sophistry."

This objection, furthermore, shows the gravest ignorance of the history and probabilities of patents. As we have before stated, useful inventions are in the rarest instances, if ever, complete and perfect inspirations. An idea—for instance, the idea of the telegraph, or of the pneumatic process, may be instantly conceived—but undeveloped ideas are not the subjects of patents. Before the law recognizes them, they must be clothed in working bodies, so that the law can see that they will perform the functions claimed. Now, the ideas of decarburizing cast iron by air and by ore, were not only known a century ago, but were practiced before the reader of this paper was born, and have been, in various partially-developed shapes, patented from time to time for years. Surely we have all had not only an untrammeled chance to invent the Bessemer and the Ellershausen processes, but we have had a very close guidance to them in the experiments and practice that preceded them; and we can no more fairly quarrel with the law that protects them to Bessemer and to Ellershausen, than we can with the law that keeps our hands out of the strong-boxes of Stewart and Vanderbilt. We have had just as fair a chance, under the law, to make the fortunes of the latter, as we have had to make the inventions of the former.

But above and beyond the *policy* of protecting patents, there is the question of *right*. Upon this Mr. Greeley says in his political economy, now in course of publication: "The rights of those who create intellectual property are less clearly defined—perhaps less capable of unerring definition—than those of the producers or transformers of material substances; yet they seem to me not less real, beneficent, and defensible. Let us suppose that four brothers commence responsible life with equal patrimonies, equal capacity, and like habits of industry, temperance, and frugality. Twenty years afterward, one of them, who has devoted his energies to farming, has a fine estate, a commodious dwelling, a handsome herd of cattle, a good collection of implements, a library, and all the material elements of independence and comfort. A second has addressed himself to the construction of locomotives, and has done as well thereby as his farming brother. A third has given himself up to the study of mechanics and engineering, and has, after

many disappointments, perfected a new steam-engine, whereby the power required to move a train or boat of so many tons, at a given rate per hour, is reduced at least twenty-five per cent. The fourth has addicted himself to literature, art, and poetry, and has produced a book which one hundred thousand of our people annually read, deriving pleasure and instruction therefrom which they would rather pay him for than forego. I ask why this inventor, and this author, have not as fairly earned, and are not as justly entitled to, the price that others prefer to give rather than forego the advantage or pleasure derived from their products, as are their brethren, the farmer and the locomotive-builder, to a like remuneration for the use of *their* products? If, as Thiers forcibly says, 'The indestructible foundation of the right of property is labor,' then, surely, the right of property in Elias Howe to that combination of the needle with the shuttle which gave practical existence and value to the sewing machine, of Alfred Tennyson to 'The Princess,' 'Maud,' 'In Memoriam,' and 'The Lotus Eaters,' is as perfect as any right of property can be. For the craftsman merely fashions, adapts, or recasts, materials co-existent with the earth, and which may be regarded as in some sense once the common property of mankind; while the inventor, the poet, builds into the void space, makes chaos luminous, and adds potentially, and as it were by original creation, to the enduring wealth of mankind. I cannot perceive how or why his right of property in his products is not at least as perfect and pervading as that of the maker of a locomotive, the grower of grain.

"I have considered what has been urged in favor of a restriction of this right of property to the material thing wrought upon — to the particular locomotive built by the inventor, the author's manuscript copy of his poem — and it seems to me palpably absurd. For what the inventor has labored twenty years to perfect is not the single, particular locomotive on which he expended his handiwork, but *all* locomotives to be thereafter built — his efforts were incited and upheld by a desire to make *all* locomotives henceforth less costly or more efficient. This he has achieved, or nothing; herein he has succeeded, or not at all. Once completed, the machine whereon he has labored so long may accidentally take fire and burn to ashes, yet no one, surely, would thence infer that his labor had been in vain.

"As to the abolition of the patent system, which has of late been influentially advocated, I shall be more easily reconciled to it when I learn that it is to be swiftly followed by a repudiation of *all* rights of property whatever — or, more strictly, of all legal guaranties and defenses of such rights. Whenever the laws of my country shall refuse to protect the inventor, they should, in simple consistency, bid the land-owner, the bond-holder, the merchant, the banker, 'Take care of yourself, and of all that you call your own!' Assuredly, no man's right to the wild lands conceded to his ancestor by a European monarch who never saw, and knew not how, even to bound them accurately, can be better than that of Eli Whitney was to his cotton gin, or that of Daguerre to photography. When these shall be successfully denied, be sure that *no* rights of property can be secure.

"'Then, why not make patents and copyright absolute and perpetual?' is often asked. I answer, there are *no* absolute rights of property. The land you bought of the Government yesterday may be taken from you for the bed of some highway or railroad to-morrow, and you have no redress. *All* rights of property are held subordinate to the dictates of national well-being; and the Government will batter down or burn to ashes your house, if it shall have become (through no fault on your part) a harbor or defense of public enemies, and make you no compensation therefor. I only insist that intellectual property shall be recognized by law as standing on a common foundation with other property and equally accorded the protection of the State and the respect of all who hold property no robbery, but justly entitled to deference and support from the wise and the good."

In the discussion of this subject "Engineering" reviews, at some length, the more important inventions now in successful use, and they are of a thousand times more value to the public than to the inventors, large as the aggregate royalties must be. We quote the remarks of our cotemporary, not only to show how little legislators and anti-patent law agitators, like Sir Roundell Palmer (to whom these considerations are addressed), are likely to know about what they are talking, but also to remind the profession and inventors of the greatness of the field in which they are called to labor, and of the inspiring success already achieved.

"Of modern inventions there are, literal-

ly, hundreds which, we have reason to believe, would have failed to establish their value to their authors, and especially to the public, but for the protection of the patent laws. Of hundreds of these, we firmly believe Sir Roundell knows absolutely nothing at all, and this, although many of these very inventions have received his own fiat as Attorney-General. Were it possible for him, and, we will add, for Lord Stanley as well, to leave, for a week, the oppressive atmosphere of politics and law, and devote one-half of that time to a rapid survey of recent successful inventions, both would form views very different from what they expressed in the House of Commons last Friday evening. Each pitched upon the steam engine, the electric telegraph, and the screw-propeller as distinct substantive inventions; and yet it is absolutely impossible to say who 'invented' either of them, although it is easy to name from half a dozen to a score of inventors, in the respective cases, who contributed greatly to the success of these inventions, and each of whom deserved, so that his claims were justly and exactly specified, such reward as a patent best affords. To any one who knows the history of these great inventions, it is absurd to say that James Watt, Professor Wheatstone, and Mr. Francis Pettit Smith were THE respective 'inventors,' although, in each case, they opened more ground, and to better purpose, than any inventors who had preceded them. James Watt, taking the steam engine in the imperfect, but yet effective, state in which he found it, invented the separate condenser, the steam jacket, the parallel motion, the sun-and-planet motion, and other details, and in his best practice his engines consumed 10 lbs. of coal per indicated horse power per hour. At the present time, non-condensing engines, the 'invention,' possibly, of Trevithick, work without separate condensers, without steam jackets, without parallel motions, and without sun-and-planet wheels, with a consumption of but from 3 lbs. to 4 lbs. of coal per horse power per hour. To enumerate the patented meritorious improvements in the steam engine would require much space, but Sir Roundell Palmer would find no difficulty in obtaining a knowledge of them were he to place himself in communication with any of our leading mechanical engineers.

"In other branches of engineering the modern, patented, *meritorious*, inventions are so numerous that it is difficult to bring them within the limits of a catalogue *raisonné*. We might mention five hundred as easily, but for limits of space, as one hundred, and as it is certain that none of us know the full width of the field of invention, there are probably other hundreds of valuable inventions of which a single writer may be ignorant. Again, for the principal patents obtained for important inventions many subsidiary patents are granted for details useful in working them, just as the 'Bessemer process' is protected by, in all some dozen of patents, each of which possesses a certain value, and is therefore meritorious.

"It would be a long list were we to record the modern meritorious inventions relating to the manufacture and working of iron. Quite apart from the more recent and suspicious patents obtained by Heaton, Radcliffe, and Richardson, and on the other hand apart from the grand series of patents in Bessemer's name, there are, among patents, in force or lapsed, Siemens' furnace, which melts iron of any quality as if it were wax; Aitken's kilns for coking carbonaceous ironstones; Bourdon's (Morrison's) coal-washing machine, whereby excellent coke is made from the most sulphurous refuse known as coal slack; While's continuous blooming mill; the steam hammer; the self-acting steam hammer; Ramsbottom's duplex steam hammer; Davies's steam striker, the most pliant, adaptable and intelligent steam hammer yet contrived; Ryder's forging machine, as effective as it is noisy; Haswell's, and Shanks', and Kohn's hydraulic forging presses; Garforth's steam riveter; Bertram's admirable system of gas-welding boiler, beam, and girder plates, so well worked out by the Butterley Company; Root's blower, the finest blast engine for foundrymen yet schemed; Woodward's steam jet cupola, which dispenses with mechanical blowers of every kind; Jobson's, Howard's, and the Anderston Foundry Company's systems of machine moulding; Hetherington's system of plate moulding; George Scott's superlatively beautiful system of mechanical wheel moulding; Deakin and Johnson's process for punching steel tubes—a process which, when we reported that a 10½ in. hole had been punched 4 ft. deep through a 3 ton ingot appeared incredible to many of our readers; Hawksworth and Harding's even more wonderful process of cold "drawing" steel tubes, of any and every section, from hollow ingots; and, finally, Westwood's hy-

draulic press for bending the thickest armor plates, even up to 14 in. thickness. Were it not that Sir Roundell Palmer and Lord Stanley had delivered themselves so authoritively upon the whole range of invention, we should not have presumed to ask them how much they know of any one of the inventions we have mentioned. Unless "coached," we will venture the assertion that, if examined, competitively, they would both be found absolutely ignorant of nearly every one we have named, and yet each of these patents deserves, and properly managed, is likely to realize what either Lord Stanley or Sir Roundell Palmer might consider a very handsome fortune. And without the protection of a patent no man of business, in his senses, would care to work them at all, unless *en amateur*.

"Then there is another wide class of inventions relating to railways and railway rolling stock. There is the fish-joint—Mr. Bridges Adams's fish-joint after all the hubbub raised about it eight years after the expiration of his patent; the cast-iron pot sleeper (poor Greaves!) Ransome's and Vickers' crossings; Arbel's stamped wheels; Mansel's wood wheels; Beattie's clip fastening for the tyres; half-a-dozen oil-tight boxes; Clark's and Fay's continuous brakes; Sterne's capital buffers; Saxby's signals, which, we sincerely believe, have, by this time, saved the lives of ten thousand of Her Majesty's subjects; Ransbottom's trough for supplying tenders while on the way; ditto, his safety valve, and, ditto, his lubricator, both good things of their kind; Naylor's excellent safety valve; Bourdon's magnificent invention, though after all akin to Salter's balance, for weighing steam; Giffard's dynamic paradox, known as the Injector, and Schau's simpler and cheaper edition; Green's useful invention for drawing tubes from brass, and, finally, an invention of great intrinsic worth—Dudgeon's tube expander. How much do you know of all these, or any of them, Sir Roundell? Don't think us impertinent.

"Turn which way we may, we find almost innumerable recent, meritorious patents. In civil engineering we have Mitchell's screw pile, which has saved untold thousands of pounds in the cost of fixing uncertain foundations in India; Dr. Pott's system of pneumatic sunk cylinders; Hoffman's annular kilns for burning bricks; Dennet's fireproof flooring, now adopted in all the principal buildings in progress in the kingdom; and Clayton's well-designed machinery for brickmaking.

"In stone-working we have (and we should be sorry to be without) Blake's stone-breaker; Holmes's stone-dressing machine; Ransome's grand invention of artificial stone — an invention possibly worth more than Columbus' discovery of San Salvador; M. Sommelier's (*Anglice*, Mr. Butler's) tunneling machine; and, finally, Mr. Doering's and Mr. Lowe's machines for the same purpose.

"In connexion with the cotton manufacture less can be said. It is an industry which admits of but moderate progress, unless some new Hercules comes to our aid. Mr. Richard Roberts *was* a Hercules in this branch of engineering. There are Wellman's self-stripping cards; Leigh's top rollers; Hetherington's wonderfully simplified mule; the Blackburn "Slasher;" Messrs. Harrison's astonishing improvement upon all the space, tediousness, dirt, and cleaning of the dressing machine that had gone before it; and, finally, Bullough's loom patents, which have added a million of money to the wealth of Lancashire. To these may be added, with a qualified opinion of their merits, a nameless number of cotton gins; and in this and kindred branches of invention, there is not so industrious a patentee as John Platt, M. P., whose authority is quoted against patents, but who is, himself, an insatiate patentee, as well as an enterprising appropriator of ideas, supposed to be covered by patents in other men's names.

"Then comes the old class of patents relative to grinding flour. First there is the decorticator, worth a million in good hands; but, possibly, before it, the grain drier, upon the results of which so many fortunes hang. Again, there is Bovill's patent, renewed, against which so many millers fought, and to which so many surrendered. Then there is Golay's diamond machine for dressing millstones, sold for ever so many thousands of pounds, Brackshaw's grain elevator, and, going back for some years, Goucher's capital beaters for thrashing machines.

"In steam-agriculture there have been such improvements that we hardly know how to begin. The grand brain who did more for steam cultivation than any thousand men now living was John Fowler, long since in his grave. Sir Roundell Palmer, we presume, would, were it in his power, annihilate the industry growing out of Mr.

Fowler's inventions. His steam plough, his clip drum, his slack gear, are all unique, and long settled practice has proved that their value might be counted rather in millions than in thousands. And no industry he had to fight harder for existence: fights of which Sir Roundell probably knows nothing at all, for, had he known of them, he could not, as a gentleman, have spoken as he did last Friday evening.

"Then, again, in connexion with steamships. There are Cunningham's self-reefing topsails; Trotman's anchors; Clifford's boat-lowering apparatus; McFarlane Gray's steam steering gear; Robert Griffith's big boss, two, or three-bladed screw propeller; the engine-room indicator; Morton's ejector-condenser; Robertson's ashes ejector; and, to go from little things to great, Penn's trunk engines, and, of far more value than anything else ever invented in connexion with the screw engine—wood bearings—one among the grandest inventions of the present generation.

"Again comes another class of invention, viz., those for lifting and hoisting. Among these Edwin Clark's hydraulic graving dock stands first in importance; and, next to that, the various plans for hydraulic jacks, as well as Weston's pulleys, and the derrick crane made by Bowser and Cameron.

"But among the valuable miscellaneous patented inventions who shall draw the line? There are the patents for Dr. Dauglish's aerated bread; the American sewing machines; Anglo-Franco velocipides; Chappuis' daylight reflectors; Bunnett's coiling shutters; Betts' capsules; Wheatstone's private telegraph; Wheatstone's crytograph; Richards' indicator; Dunbar's apparatus for charging and drawing gas retorts; Perin's band saw; Chatwood's safe; dozens of inventions of breech-loading rifles; the Manchester water meter; Bailey's oil tester; a lot of American inventions for gas regulation and gas carburation, as well as for tin-lined lead pipe, the latter manufacture based upon the "flow of solids," commercially worked some years before M. Tresca's ingenious researches at the *Conservatoire des Arts et Métiers*, in 1866. There is the magnetic anti-incrustator, Siemens' gyrometric governor, Mallet's buckle plates, the Abyssinian tube well, Lloyd's fan, Robertson's frictional gearing, Dellagana's paper stereotype moulds, Gaine's parchment paper, Young's paraffine oil patent, Moncrieff's gun carriage, Hugon's gas engine, Armstrong's beautiful dove-tailing machine, Robert's elegant "diffusion" process for making sugar, Seyrig's centrifugal machine for drying sugar and other substances, the revolving magnetic machine for separating iron from brass turnings, Needham and Kite's yeast press, Harrison's ice-making machine, Carr's beautiful disintegrator, Peet's valve, Chatterton's compound for submarine cables, Webster's ferro-zinc paints, Moule's earth closets, Liernur's sewage system, Sillar's precipitating compound for sewage, Worssam's silent feed, Palliser's bolts, Batho's nut shaper, Sellers' bolt cutter, Perkins' sealed heating pipes, Porter's governor, Armstrong's hydraulic machinery, coal cutting machinery, Upward's drilling apparatus for gas mains, Garside's electograph engraving machine, Livesey's newspaper folding machine, various excellent refrigerators, King's malt measurer, and so on, in an almost endless list.

"Valuable as these inventions are, it has required a vast aggregate expenditure of time and money to induce the public to believe in, and adopt them. None, assuredly, knowing the task would have undertaken it without some hope of substantial reward, and patents appear to be the only rewards available. The inventions enumerated bear no proportion in number to the hundreds of useful modifications and combinations of modern machinery which are valuable rather for their simplicity and convenience than for any distinctive mechanical principle."

MARINE ENGINE PROGRESS.

From "Engineering."

Not middle-aged engineers alone, but comparatively young engineers as well, have had occasion to remark the wonderful rapidity with which the marine engine practice of any given period may become obsolete. The grand old side-lever engines of twenty years ago, or for that matter ten years ago, are fast becoming curiosities possessing a high degree of archæological interest. It will not probably be long before the 100 in. cylinder, 12 ft. stroke engines of the Scotia, only finished in March, 1862, will be replaced by screw engines, as has been done already in the case of the Persia. We have only to look back to 1847 to find but 156 steamers built and building in the British Navy, none of them exceeding 1862 tons, or 800 nominal, equal only to about 1500 indicated, horse power. The Greenock, the

Phœnix, the Rattler, the Fairy, the Bee, and the Dwarf were the only screw vessels, although the Amphion, Arrogant, Conflict, Dauntless, Desperate, Encounter, Euphrates, Megæra, Minx, Niger, Rifleman, Sharpshooter, Simoom, Termagant, and Vulcan—all screws—were in progress.

There is little reason to doubt that the opinions of marine engineers were as fixed and as strong, in 1847, as they are now, and then it was then believed that science and skill had done well nigh all that was practicable for the improvement of the marine engine. The steam was low and the speed was slow; the former from 5 lbs. to 10 lbs., the latter from 140 ft. to 260 ft. of piston per minute. The Alecto with 4 ft. 6 in. stroke, made but 14 revolutions per minute in regular work, or 126 ft. of piston, and even the Avenger, with 650 horse engines, 6 ft. stroke, made but 13 revolutions or 156 ft. of piston per minute. The Dee, with 200 horse engines, 5 ft. stroke, made but 12½ revolutions, or 125 ft. of piston per minute. The Thunderbolt, with 300 horse engines, 5 ft. stroke, made but 15 revolutions, the Salamander, with 220 horse engines, 5 ft. stroke, made but 14 revolutions, and even the Victoria and Albert, with her original 400 horse engines, 6 ft. stroke, made but 17 revolutions of her 30 ft. wheels, corresponding to but 204 ft. of piston per minute.

There were many who disbelieved in the screw altogether, and its introduction into war ships was partly if not greatly due to the circumstance that the screw engine and propellor could be kept wholly beneath the water line, and that the deck was left clear for its whole length for armament. As for merchant steamers, it was long before steamship owners would listen to any arguments in favor of the screw.

It was even doubted whether screw engines could be practically worked at the high speed required by the screw, and gearing was often employed, as in some cases it is still. With injection condensers, and the old forms of flue boilers, steam of more than 10 lbs. per square inch was considered out of the question at sea; expansion was seldom practiced to any extent, and superheating was reckoned a costly and needless refinement, if, indeed, it had been thought of at all. The whole ground opened by the introduction of the screw was beset with difficulties, and but few were willing to believe that these could ever be overcome. The screw vibrated greatly, and came well nigh shaking the stern post out of the ship, and it was next to impossible to keep the screw shaft tight in the stern tube. Direct double-acting, full stroke air pumps, too, knocked their valves to pieces very quickly.

Marine engine improvement has consisted in doing just what twenty years ago was reckoned impracticable or inexpedient. The tubular boilers that were to give so much trouble by salting and leaking are now in universal use, and a flue boiler of 1850 would be reckoned a curiosity. The pressure of steam has been carried to 25 lbs. or 30 lbs. in regular work, while Mr. Elder's boats, and the Sirius, engined by Maudslay, are worked to 50 lbs. The piston speed has been carried, as a maximun, to 600 ft., and even 650 ft. per minute. Indeed, Mr. Bourne once worked a single cylinder engine of 3 ft. 6 in. stroke at 100 revolutions per minute. Superheating is now practiced with advantage and a good degree of expansion attained, in some cases with compound, or high and low pressure engines. Surface condensation, with all the cost, weight, and bulk of the tubes, and the difficulty, once encountered, of keeping them tight, as well as the danger, at one time so imminent, of corroding the boilers, is now a firmly established fact. Double-acting air pumps, making 75 double strokes, and 600 ft. of bucket per minute, work as easily and silently as the old air pumps, worked, off the beam or side-lever, at 80 ft. or 100 ft. with only but 15 or 20 double strokes per minute. The vibration of the screw has been well-nigh stopped by Griffiths' improvements; its stern bearing is now the most durable of all, since Mr. Penn applied wood bearings and the dynamic performance of large screws of fine pitch is in all respects equal to the best results obtained from paddles, while the machinery required to drive it is, of course, far lighter in respect of weight. Were we now to return to Boulton and Watt's old practice of 7 lbs., effective cylinder pressure per square inch, and 204 ft. of piston per minute for a 4½ ft. stroke, it would require a pair of engines of 29 ft. 6 in. (354 in.) cylinder to develope the power of 8,500 horses, indicated on the trial of the Hercules. The revolutions would be 22⅔ only per minute, requiring gearing in the ratio of about 3¼ to 1 to get up the 72 revolutions actually attained by the Hercules' screw. No comparison possibly could better mark the progress already

made in marine engines. But if we address ourselves to an inquiry as to the limits of further improvement, we are confronted by seeming impracticability or impossibilities, such as stopped the way twenty years ago. To what point may the pressure be yet carried in practice? To 100 lbs., or more? Rowan worked 130 lbs. at sea; but his boilers gave trouble. Of course, with very high steam, superheated and condensed after exhaustion, a rate of expansion of 12 or 16-fold is practicable. As for piston speed, it may, possibly, be yet increased to the rate occasionally attained in locomotives, say to 900 ft., or even 1,000 ft., per min.; but we are all disposed to be incredulous as to the continuance, and especially the economy of such speeds. But, as abstract facts, we do know that steam engine economy is to be sought in high pressures, high speed, and high expansion.

It is a question whether the hot gases escaping at the chimney might not be advantageously forced into the boiler, below the water line, and be thus made to give off their heat. For every ton of carbon burnt from 6 to 7 tons of water are evaporated, while, also, $3\frac{2}{3}$ tons of carbonic acid are sent up the chimney at a temperature of perhaps 600°. That there is a considerable loss here is indisputable. The only question is, how may it be prevented, the presumption being that the cost of securing this waste heat would be greater than it would be worth when saved. Air, too, forced through a heating apparatus into the water in the boiler, or into the steam, would possess a theoretical advantage, and we hear of one or two patentees who are already experimenting in this direction, among them Mr. Richard Eaton, of Nottingham.

STEAM ON CANALS.

PROPULSION BY A FIXED WIRE ROPE AND CLIP-DRUM — EXPERIMENTS IN BELGIUM.

From "The Engineer."

A series of highly interesting experiments, or rather a general exhibition of the first line of considerable length, on which a new principle—the application of wire rope and clip-drum for river navigation — has proved practically successful, took place on the 4th and 5th inst. between Liège and Namur, in Belgium. The governments of England, France, Prussia, Austria, Wurtemberg, Holland, and Belgium, sent their special engineers; the Suez Canal Company, and steam navigation companies from the Danube, the Elbe, the Rhine, and the Rhone, were represented, and the presence of gentlemen from almost every country in Europe proved the importance which must be attributed at the present moment to all successful improvements in the methods of inland navigation on rivers and canals.

The Meuse has, between Liège and Namur, a length of nearly seventy kilometers (forty-four miles), leading through one of the principal coal districts in Belgium. The river forms one of the most important links of the long chains of canals and streams which connects Belgium, and particularly Antwerp, with Paris. A company, the Société Anonyme Liègeoise de Tonage, received a year and a half ago the concession for supplying the system patented by Bon. C. de Mesnil and M. Eyth to this line, and began their operations by laying an iron wire-rope of 1 in. outside diameter on the bed of the river. There are eleven locks to pass, which do not interrupt the continuous length of flexible rail thus placed in the axis of the whole water-course. Small holes are provided in the gates near the sill, so that the wire passes through the locks without interruption, and the gates being opened are perfectly free to be moved by the machinery. The only places where the rope is actually fixed or moored are two temporary ends at Liège and Namur, everywhere else it follows in a comparatively slack state all the bends and curves of the center line of the river. The mechanical principle of the system now consists in mounting on the tug-boat which carries the machinery a clip-drum, vertical or horizontal, which takes hold of the rope, the boat taking it up from the river bottom by suitable pulleys near its bow, and dropping it again near the stern into the water. The clip-drum, turned by the steam machinery, will thus haul the boat along the so-called fixed rope, pulling, in fact, on the weight of the wire and the frictional resistance of the same on the river bottom. In principle, therefore, the idea is the old one of chain navigation, as applied during the last twelve years or so on the Seine. But the practical difficulties which prevented the more general introduction of the latter, in spite of the great advantages inherent in the principle, are avoided in the new methods to so considerable a degree that M. Eyth's system seems to be destined to raise again inland navigation to the relative importance

which its physical peculiarities warrant, and which it has, in most cases, lost by the introduction of railways.

The first tug of the Société de Tonage started on the line on which the experiments took place about a year ago. It is an iron boat, flat-bottomed, of twenty meters length, four metres width, 2.25 meters depth of hold, drawing 0.95 meters, and carrying a 14-horse power horizontal, double-cylinder, high-pressure engine. This engine works a vertical clip-drum on the side of the boat, of 6 in. diameter, over which, by means of two guide pulleys of the same diameter, the wire rope takes half a turn. The machinery was constructed, like that of the greater number of cable tugs now in Belgium, in England, by Messrs. John Fowler & Co., Leeds, who have made the construction of this sort of boats one of their specialities.

The speed of the clip-drum can be altered by suitable gear, thus giving ten, five, and two and a half kilometers, or rather more than one and a half miles per hour, to the tug. The first was intended to be used in towing down stream; but it was found that, with long trains in sharp bends, it could not be worked safely, and that the speed exceeded the requirements of the trade. The gearing proper to it was therefore removed. The speed of two and a half kilometers is only used in winter, for towing up-stream in the most rapid currents, which may amount, in certain places of the river, to ten or twelve miles an hour. The greatest amount of work done by this tug is, if going up-stream, at the rate of four miles an hour against an average current of two or three miles. Working with the full power of two 7¾-in. cylinders, 12 in. stroke, seventy revolutions, 80 lbs. or 90 lbs. pressure, it towed 1,500 tons of freight, as taken in ten boats of varying burdens; also, on another occasion, 1,000 tons of freight in eighteen boats more or less freighted. During winter the tug worked against currents, which the 45-horse power passenger steamers of Seraing were not able to overcome; 400 to 500 tons freight were taken in three boats, with the speed of two and a half kilometers, keeping thus the navigation open during a season which, up to now, was considered lost for the boat interest of the Meuse.

In consequence of the great delays at the locks, if towing considerable trains, the average mileage of the tug per day is small, amounting only to about forty-five kilometers, and being about double of what is done by horse towing on the same line. But the Belgian government, being satisfied of the beneficial influence this enterprise already effects on the movement of the river, have now decided to increase the dimensions of the locks, so that in future a whole train will be locked through at a single operation. So the mileage may be raised in future to fifty or sixty miles a day easily.

The coal consumed per day of ten hours was about half a ton, the ton costing 11½f. on the boat. There are five men on board, a captain or pilot, two sailors, an engine driver, and a fireman, and the total monthly working expenses amounted to about 600f. (£24). In towing 800 tons thirty-five kilometers per day, which may be considered at the present moment an average performance of the tug, the daily receipts are under the present tariff of 0.006f. per ton and kilometer (about one-third cheaper than horse towing for hire), 168f. Now the tug requires two days to go the seventy kilometers from Liège to Namur, and comes back frequently empty in one day. It has, therefore, twenty working days in the month, which pay, and the whole monthly receipts (if nothing is to be towed down stream), are 3,360f. (£134). Three more tugs are now in the possession of the company, of which two were successively tried during the experiment. They worked, especially in the sharp bends and considerable currents above Seraing, with regard to hauling and steering, with a steady ease which left nothing to be desired. It was generally feared that sharp bends with strong currents would be fatal to the system. These tugs are five meters longer, carry engines of 20-horse power, and differ in their constructive details considerably from the original type. They are all provided with an auxiliary screw, so that they can moor independent of the rope if required. This gave, some weeks ago, an opportunity of carrying out a very interesting experiment. The whole power of the engine can be brought to bear on the screw, and in that case the propeller was able to tow a 250-ton boat against the average current of the river, but no more. Working by means of the wire rope, she towed with ease five times as much at the same rate. It must be said that the form of the tug and the dimensions of the screw are not the most favorable for the propeller, and some 20 or 25 per cent more might be got out of more suitable proportions. Still, taking in account everything in this direction, there remains an ef-

fect of the engine about three times greater when working with the clip-drum than if using the screw.

Besides the line on the Meuse, there are now wire ropes on the Canal de Chaleroi, in Belgium, on the Canal de Beveland, in Holland, and on the Canal de Terneuze, which connects Ghent with the Schelde, and a short experimental rope for the Rhine. Considering the short time the idea has had for its practical development—the first experimental machinery being made in Leeds in 1866—these results speak for its importance and the undoubted success it has obtained on the lines in actual operation.

THE MANUFACTURE AND USE OF PORTLAND CEMENT.

BY DR. W. MICHAELIS.

Condensed and translated from "Polyt. Centralblatt."

Cements may be divided into two classes, the Roman cements and the Portland cements. The Roman cements are made from earths found ready in nature, especially in the Jurassic rocks. Their name was given to them by Parker, who was the first to use the limestone nodules of the island of Sheppey for the preparation of a water-mortar or cement, which is very similar to the mortar made by the Romans from puzzolana. Portland cements are generally water-mortars that are prepared artificially by grinding and mixing different natural substances. When hardened, they resemble in color and durability the celebrated Portland stone. They have, therefore, been designated by the same name by Aspdin, the inventor of the first artificial cement.

The principal distinction between Roman cement and Portland cement lies not, however, in their origin, but in their different physical condition, caused by different methods of calcination. Roman cement is a fine dust-like powder, partly of a light, partly of a dark reddish-brown color. It absorbs carbonic acid and water eagerly, and cannot, therefore, be stored for a long while. Portland cement, on the contrary, is a powder consisting of fine crystalline scales of a dark-grey, somewhat greenish, color, much heavier, absorbing carbonic acid and water less rapidly, so that it may be stored for some time. It is calcined at a considerably higher temperature than Roman cement.

Portland cements are considered the best water-mortars. Being artificially prepared, they can be obtained more homogeneous and uniform than the Roman cements, which vary too much in their composition.

The following analyses of some Roman and of some Portland cements show this distinctly:

ROMAN CEMENTS.

	1.	2.	3.	4.	5.	6.
Lime	53.38	55.60	47.83	53.88	68.8	78.31
Magnesia	5.00	1.73	21.36	2.35	2.3	3.60
Silicic acid	27.83	25.00	5.80	23.66	18.5	13.51
Alumina	6.40	6.96	1.50	7.34	5.7	4.60
Peroxide of iron	4.80	9.63	20.80	7.97	4.4	

PORTLAND CEMENTS.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Lime	59.06	62.81	62.81	60.33	61.64	61.74	55.06	57.63	55.29
Silicic acid	24.07	21.29	23.32	23.94	23.00	25.69	22.92	23.81	22.86
Alumina	6.92	5.27	7.66	7.04	6.17	6.17	8.60	9.38	9.03
Peroxide of iron	3.41	2.60	2.51	2.46	2.13	2.13	5.40	5.32	6.14
Magnesia	1.11	1.15	.23	.....	.....	2.34	.77	1.35	1.64
Potassa	.73	1.27	.94	.....	.....	.60	1.13	.....	.77
Soda	.87	.40	.77	.30	.....	.40	1.70	.71	.....
Sulphuric acid	2.45	1.30	1.52	1.52	1.530	1.64	1.73	1.11	3.30
Insoluble clay and sand	1.47	2.54	1.32	1.04	1.26	1.13	2.27	.....	1.06

ORIGIN OF THE ABOVE ROMAN CEMENTS.

No. 1. From a triassic limestone near Rüdersdorf.
2. From limestone nodules of the island of Sheppey.
3. From a triassic limestone, covering the strata of lead ore, near Tarnowitz.
4. From Hausbergen.
5. From Metz.
6. From Holkin Mountain, near Holywell Flintshire.

ORIGIN OF THE PORTLAND CEMENTS.

No. 1. English cement from White & Bro.
2. From Stettin.
3. From Wildau.
4. From Wildau.
5. Pomeranian Star cement.
6. From Stettin.
7. English cement.
8. From the Bonn Mining Company.
9. From Kraft & Sanlich, at Perlmoos.

MANUFACTURE OF PORTLAND CEMENT.

Suitable limestones and certain kinds of clays are selected, mixed intimately in certain proportions, and calcined at a high temperature. The carbonic acid gas separates from the lime at a moderate red heat. But the mixture for Portland cement has to be subjected to a higher heat, because the hydraulic properties of the cement increase, to a certain extent, with the temperature at which it is calcined. It ought to be softened by the heat, but not so much as to assume the dense structure of a melted mass. This is effected at a white heat. The clay is thereby completely decomposed through the action of the lime, and silicate and aluminate of lime are formed. The calcined mass contains, besides these two compounds, which are its principal constituents, smaller quantities of silicate of alcali, silicate and aluminate of magnesia, and, perhaps, some sulphate and phosphate of lime.

The calcined mass is ground fine, mixed with a little water and worked into a paste. Cement thus prepared hardens more and more, the longer it is exposed to water, or to atmospheric air. Good Portland cement gets as hard as fluor-spar, and equals the best limestones in solidity and durability.

SELECTING AND MIXING THE MATERIALS.

Any kind of carbonate of lime is fit to be used in the manufacture of Portland cement. Marble, limestone, chalk and marl may be used. Chalk and marl often include foreign matters, such as flints, feldspar, sand, which have to be removed by washing.

The clay used must be of a certain chemical composition, which can be seen from the following analyses of celebrated kinds:

	1.	2.	3.	4.	5.
Silicic acid	68.45	60.00	59.25	60.00	62.48
Alumina	11.64	17.79	23.12	22.22	20.00
Peroxide of iron	14.80	7.08	8.53	8.99	7.33
Lime	.75	9.92	.....	4.18	6.30
Magnesia	.....	1.89	2.80	1.60	1.16
Potassa	1.90	2.50	1.87	1.49	1.74
Soda	2.10	.73	1.60	.72	.37
Sulphate of lime	.....	.60	2.73	.89	.60

ORIGIN OF THE ABOVE CLAYS.

No. 1. The celebrated Medway clay.
2. From the Prussian Province of Saxony
3. From Pomerania.
4. From the Upper Hartz Mountains.
5. From the Province of Brandenburg.

It is to be seen from the above analyses that the clays most adapted for the manufacture of cement contain considerably more silicate of alumina than kaolin does. Lime and clay have to be mixed very intimately. If this condition is not fulfilled, a good cement can never be obtained. The most perfect method of doing this is to mix them when suspended in a large quantity of water. However, the success of the manufacture depends not only on a thorough mechanical mixing, but also on the proper chemical composition. A careful examination of a large number of good Portland cements has shown that the proportions of the three principal components ought to be within the limits indicated by the following two examples of composition:

I. 80 equivalents of Si O^2 (silicic acid).
210 " " Ca O. (lime).
27 " " Al^2O^3 (Fe^2O^3) (alumina and peroxyde of iron).

II. 30 equivalents of Si O^2 (silicic acid).
230 " " Ca O (lime).
15 " " Al^2O^3 (Fe^2O^3) (alumina and peroxide of iron).

Supposing the sesqui-oxydes to play the part of acids, these two compositions correspond to the formulæ:

$$\text{I. } 10\ Si\ O^2\ (R^2\ O^3) + 20\ Ca\ O$$

(10 equivalents of silicic acid and sesquioxydes, with 20 equivalents of lime).

$$\text{II. } 10\ Si\ O^2\ (R^2\ O^3) + 24\ Ca\ O$$

(10 equivalents of silicic acid and sesquioxydes, with 24 equivalents of lime), which represent the limits of the composition of good Portland cement, and are of great value in preparing the mixtures of lime and clay.

The following facts will give an idea of the hydraulic properties acquired by the single components of cement, when they are mixed with other components and calcined: Silicic acid and lime are the most important components of cement in quantity and quality. When mixed together and calcined they form a compound which hardens under water. Not only amorphous silicic acid produces this effect, but also crystalline quartz, when heated with lime to a white heat. Carbonic acid affects and decomposes silicates of lime. The artificial silicates resist this decomposition the better, the more compact and dense the silicic acid was, in its raw state. Silicic acid and alumina do not alone combine chemically in water at ordinary temperatures after being calcined together.

Lime and alumina have a considerable affinity for each other. When mixed and heated they combine, and form hydraulic compounds, which harden with water perfectly well, especially when they have been

produced at a high temperature. When compounds of alumina with one, two or three molecules of lime are finely pulverized and mixed with a little water, they become binding at once and form hydrates, which get very hard under water. By mixing the aluminate 2 Ca O, $Al^2 O^3$ with 30, 60 and 80 per cent of sand, Frémy obtained a mass that assumed under water the hardness and firmness of the best stone.

Lime and peroxyde of iron form a compound when calcined together. This compound is, however, less hydraulic than the aluminate of lime.

Calcined magnesia alone hardens well with water. It also forms with silica good hydraulic compounds.

Silicates of alcali are also useful in the process of hardening.

Sulphate and phosphate of lime do not aid the hardening, and may be considered as noxious ingredients, when present in considerable quantity.

CALCINATION.

The mixture of raw materials, made according to the principles above developed, is formed into pieces of uniform size (bricks), which are dried in the air and calcined. The furnaces used for calcining are generally kilns from 40 to 50 ft. high, and from 7 to 12 feet wide. Three or four feet above the ground they contain a strong grate, consisting of single bars, which can be removed when the calcination is completed. The calcined and slightly glazed mass of bricks slides down by itself in cooling, and is then extracted. The kilns are charged with alternate layers of fuel and cement bricks. The regular shape of the bricks allows of charging the kiln in such a manner that the escape of the gases can take place uniformly, over the whole section of the furnace, to effect a calcination as uniform as possible. Coke is generally used as fuel, because it is purer than coal; the sulphur contained in the latter would give occasion to the formation of sulphate of lime. If, however, raw coal is used, the kilns must have such a construction that the fuel does not come in contact with the cement, and that only the gases produced by the combustion pass through the furnace. The annular ovens, recently patented by F. Hoffmann and A. Licht, are used with great success for calcining cement, as well as bricks, lime and pottery. In these ovens the cement also comes in contact with the fuel, but a much smaller quantity of the latter is required, and the greater part of the ashes is gathered in the charging tunnels and does not mix with the cement.

A proper temperature in calcining is a very important matter. Cement calcined at too high a heat looses entirely its property of binding. The proper intensity of heat has to be found out by experiments for every single mixture. The denser the raw materials are, the higher the heat required. Mixtures prepared from compact limestone or washed chalk require a higher temperature than those prepared with light and porous kinds of carbonate of lime. The higher the temperature required, the higher the kilns have to be constructed. The temperature varies easily to an observable extent in kilns not holding over 150 tons. But the limits within which the temperature may vary without injuring the product are pretty wide. The hydraulic quality of the cement increases with the intensity of heat used in calcining. However, this is only the case to a certain extent. When overheated, cement gets too compact, and its capacity of hardening then decreases. A white heat is the proper heat for the calcination of Portland cement. If it is heated higher, it begins to run, and is then unfit for use. The best method to judge about the temperature existing in the furnace is to take samples of the cement under treatment from time to time. As the color of the cement changes with the increase of heat, the samples taken from the furnace will show by their color and appearance how far the process is advanced, and make it possible to regulate the temperature properly. The following will explain this:

The limestone looses its carbonic acid at a low red heat. At the same time the lime begins to decompose the clay. When a good red heat is kept on for an hour the mass becomes yellowish-brown, and can then be dissolved in diluted hydrochloric acid, the larger grains of quartz excepted. The capacity of the mass for hardening is, however, small yet. It gets hot, when mixed with water, and falls to pieces, when exposed to the air, like ordinary lime. With the increasing temperature the mass gets darker brown, more resisting to atmospheric influence, more capable of hardening, less liable to develop heat when mixed with water; all of which proves that the lime combines, chemically, more and more with the silicate. When the temperature is increased to a

white heat the mass becomes grey at first, then assumes a greenish tint, which gets more and more distinct with a further increase of temperature. Up to this stage in the process of calcination the cement improves in quality, its density, firmness and capacity of hardening being increased. If the intensity of the heat still further augments, the greenish-grey color of the mass is changed into a bluish grey; and this is the stage when the cement begins to deteriorate. The mass gets more and more compact and resembles basalt. At last it enters a state of complete fusion, when it shows the appearance of obsidian, or vitreous lava. It is desirable to obtain a uniform pumice-like mass, of a greenish-grey color. Well mixed and well calcined cement ought to "stand," that is to say, it ought not to fall to pieces in cooling. This occurs, however, with burnt bluish-grey cement; and, also, with carefully calcined cement, when the chemical composition is not the right one. The more lime there is in the mixture the safer can the cement be calcined at a high heat without fear of its falling to pieces afterwards. Mixtures containing too much clay fall to pieces after the calcination. An addition of lime or alkali will prevent it, provided the cement is not burnt. The finer the condition and the more intimately the clay and the lime have been mixed, the higher can be the amount of lime used. But when the mechanical mixing has been done without accuracy and care, a greater amount of lime will only make things worse. It then does not prevent disintegration of the calcined mass, and adds, besides, another evil, causing it to become hot and to rise in contact with water. The utmost care in mixing can, therefore, not be enough recommended; for no good result can be obtained without it, whatever the proportions of the mixed substances may be. Whoever does not pay sufficient attention to this point, and attributes bad results to other causes, is inevitably led into errors and confusion.

The question, how much lime can be used, is answered by the formulæ I and II, given above, which indicate the limits. If on 10 equivalents of acids (including the sesquioxydes) less than 20 equivalents of lime are used, the cement will fall to pieces; if more than 24 equivalents of lime are used on 10 equivalents of acids, the cement will get hot with water and will not harden as a solid mass. The more lime a cement contains, within these limits, the slower it hardens, but the firmer and the more solid is the hardened mass, and the more valuable is the cement.

PROCESS OF HARDENING.

Well calcined Portland cement, when mixed with water so as to form a thick paste, becomes binding more or less rapidly, depending on its composition and on the heat to which it has been exposed. It solidifies and hardens in the air as well as under water. When hardening in the air, the cement does not lose any of the substances contained in it. When it hardens under water, a part of its soluble components, especially the silicates of alkali, are dissolved and extracted. The hardening process proceeds quicker at first in the air than in water, because carbonate of lime is then formed beside the silicate. But this takes place on the surface only, to a depth of about one-eighth of an inch. The interior mass remains free from carbonic acid and hardens equally fast in air or water.

Carbonic acid gas, though at first assisting the hardening process, effects afterwards a decomposition of the cements if they are loose or porous. Ground cement is rapidly decomposed by carbonic acid. The durability of the cement is, therefore, dependent on its solidity and density. The quantity of water that has to be mixed with the cement to prepare it for use, is about one-half the weight of the cement. This quantity is sufficient under ordinary circumstances. But in a high temperature, or when exposed to sun-heat for a long while, or when in contact with quite dry bricks, the cement may lose so much water that it cannot harden properly. It is not necessary to keep cement walls wet till the cement has hardened; but it is important to wet the bricks thoroughly before being laid in cement.

Hardened Portland cement, which is free from carbonic acid, contains 14 to 16 per cent of water. It is generally composed of:

1). Basic silicate of lime of the formula:

$$5\ Ca\ O.\ 3\ Si\ O^2 + 5\ H\ O.$$

2). Aluminate of lime (and the corresponding compound of sesqui-oxyde of iron with lime) of the formula:

$$3\ Ca\ O.\ Al^2\ O^3\ (Fe^2\ O^3) + 3\ H\ O.$$

3). Hydrate of lime. $Ca\ O.\ H\ O.$ S.

BESSEMER ROYALTIES.—The statement circulated here, that they have been, or will this year be reduced, on products for either home or foreign consumption, is officially denied by Mr. Bessemer.

BURNING COAL DUST.

From "Engineering."

Those who have carefully studied the ordinary methods of burning fuel in our steam boilers and furnaces are well aware of its numerous defects, and of the losses of heat attendant upon it. Thus, besides the losses from conduction and radiation, which will take place to a greater or lesser extent with any system of burning fuel, there are, under ordinary circumstances, the losses due to imperfect combustion, to unconsumed coal falling into the ashpit, and to the heat carried off by the waste gases escaping to the chimney, this latter loss being largely increased by the excess of air which it is found requisite to supply to the furnace beyond that required for chemical combustion alone. To avoid these losses, various plans have been devised, the most thoroughly successful in practice, as well as one of the most perfect in theory of those hitherto brought before the public, being Mr. C. W. Siemens' beautiful system of regenerative gas furnaces. As far as the results obtained are concerned, these furnaces have really left little or nothing to be desired; but they have the disadvantage of being of considerable first cost, and, therefore, although they have been very largely adopted, they have not come into such general use as their economical working would otherwise warrant.

Under these circumstances various attempts have naturally been made to approximate more or less closely to the economy of the regenerative gas furnace without at the same time involving so great an outlay for gas producers, regenerators, &c.; but—although several experimenters have obtained good results—until quite recently no plan which could be said to be a fair competitor of Mr. Siemens' system had, so far as we are aware, been brought forward. A few months ago, however, Mr. Thomas Russell Crampton commenced experimenting on methods of burning fuel in the form of powder, and the practical results which he has lately obtained are so striking that we are inclined to regard his system as one possessing very great importance from many points of view. And here we may remark that the plan of burning fuel in a powdered state is, in itself, not new. Both in this country and abroad—and particularly in America—many attempts have been made to burn coal in the form of dust or finely divided particles; but prior to Mr. Crampton's experiments these attempts met with but indifferent success. One great difficulty which troubled most of the experimenters was that the flues of the furnaces became clogged with dust, this dust consisting in a great measure of unconsumed fuel, and representing, therefore, so much waste, besides being a practical inconvenience which it was found impossible to avoid. Mr. Crampton, however, *has* avoided this inconvenience, and the arrangements he has employed to enable him to do this have at the same time enabled him to obtain other advantages, of which we shall speak in due course. In the first place, however, we must explain briefly the principles upon which Mr. Crampton's system is based—principles, we may remark, in which sound common sense occupies a conspicuous place.

If two jets, one of coal gas and one of atmospheric air, be introduced into a chamber side by side and a light applied, a long flame will, as everybody knows, be produced, the length of this flame increasing according as the pressure under which the jets of air and gas are delivered is increased. Even if the gas and air are mixed before being introduced in the chamber, and are delivered into the latter through a single jet, the flame will still be produced, the length, although less, being, as before, increased by an increase of the pressure under which the jet of mixed gas and air is delivered. Now the existence of this more or less elongated flame proves that the combustion of the gas, even when mixed with a supply of air, is far from being instantaneous, and that, in order that perfect combustion may be obtained, a certain time must be allowed to elapse before the mixed gases are brought into contact with the objects which would reduce their temperature below that at which chemical combination will take place. When the fuel is supplied in a solid instead of a gaseous form, a still longer time is necessary for the completion of the process of combustion, the larger the particles of fuel the longer being the time thus required.

It is a recognition of this fact, that *time* is required to complete combustion, that forms the basis of Mr. Crampton's system of buurning powdered fuel. Instead of projecting the coal dust into a chamber where the heat is to be utilized, he mixes it with the requisite supply of air, and delivers the mixture into a combustion chamber or flue

of such length or provided with such baffling screens that time is afforded for the combustion to be completed, before the heated gases which are produced arrive at the point where the heat is utilized. The time requisite to attain this end may be obtained by forming the combustion chamber with a zigzag flue, or by placing across it perforated screens of brickwork, which will form baffles, and delay the current of gases. In any case, openings are provided for drawing off the slag, which is deposited in the combustion chamber.

Of course the smaller the particles in which the fuel is supplied the greater will be the surface exposed by them in proportion to their weight, and the shorter therefore will—as we have already stated—be the time required for their combustion. In other words, the finer the particles the more nearly will they approach in character to gaseous fuel, and therefore if it were not for certain commercial considerations it would be advisable to reduce the fuel to the finest particles possible. Although, however, coal may, by suitable mechanical contrivances, be readily reduced to a state of impalpable powder, such reduction would be expensive, and therefore from an economical point of view unadvisable. Mr. Crampton has given this matter careful consideration, and we believe that the conclusion he has come to is, that regarded from a commercial point of view, it is unadvisable to spend more than one shilling per ton on reducing the coal to powder; or, in other words, that the coal should be reduced to as small particles as is possible for this expenditure, but that the advantages to be gained by the use of finer particles would not compensate for the extra expense of producing them.

To reduce the coal to powder, Mr. Crampton proposes to use ordinary millstones having a blast of air passed between their grinding surfaces, this blast both keeping the stones cool and carrying off the fine particles as soon as they are produced. The coal may, of course, if desired, be crushed between rollers, or by other means, before being fed to the millstones. The methods of delivering the mixture of powdered fuel and air into the combustion chamber, employed by Mr. Crampton, vary somewhat according to circumstances; the plan, however, which appears to be most generally applicable is that in which the powdered fuel is delivered from a hopper by means of a feed-roller into a coned pipe or nozzle, within which is a smaller nozzle discharging air under pressure. A kind of injector is thus formed which delivers the mixed air and powdered fuel into the main pipe leading to the combustion chamber, this pipe being traversed by a current of air under a low pressure. In this arrangement the feed-roller can receive its motion from a little engine directly attached to it, this engine being driven by the compressed air supplied to the injector nozzle. Where the furnaces are distributed about the works, the employment of little independent engines in this way will be a great convenience, and will save the erection of shafting.

We have said that the experiments already made by Mr. Crampton on his system have given most satisfactory results, and we hope to be able in an early number to lay the full details of these results before our readers. In the meantime, however, we may point out some of the advantages which Mr. Crampton's system appears to us to possess. In the first place, besides enabling ordinary good small coal or slack to be efficiently consumed, it affords great facilities for burning coal of inferior qualities. Take, for instance, coal containing a large proportion of sulphur. In order that such coal may be utilized for metallurgical operations in ordinary furnaces, it is requisite that after being powdered and subjected to a washing process, it should be moulded by pressure, &c., into blocks, while by burning it in the powdered state all the moulding process would be dispensed with. In cases when the coal merely contains an admixture of earthy matters, unaccompanied by deleterious volatile ingredients, the advantages in favor of Mr. Crampton's system are still greater. In such cases it is not even requisite that the coal should be washed, it being merely necessary to reduce it to powder, the presence of the earthy matters merely increasing the quantity of slag deposited in the combustion chamber without interfering with the perfection of the combustion. In dealing with the poor coals of India and similar fuel this would be an important consideration. Another advantage consists in the saving of labor effected, the supply of the powdered fuel to the furnace being regulated merely by opening or closing a valve, while there is the further advantage that the supply of air needed is little if any greater than that required for chemical combination, so that the intensity of the heat attainable is far greater than in an ordinary furnace

where there is necessarily a surplus of air present. As a result, moreover, of the nicety with which the supply of air can be adjusted, the formation of smoke can, as the trials have shown, be completely avoided. Again, the system offers great facilities for utilizing the heat which would otherwise be carried off by the waste gases, it being merely necessary to pass these gases through regenerators arranged on Mr. Siemens' plan, and employ these regenerators to heat the air which is mixed with the coal dust in the first instance. In reheating and other similar furnaces, also, the fact of a slight pressure being maintained within the furnace is an undoubted advantage, as it prevents the indraught of cold air through crevices, or when the furnace doors are opened. Altogether, we consider that Mr. Crampton's system of burning powdered coal fuel is one which is well worthy the attention of all interested in the economy of fuel, and we anticipate that it will come into extensive use. We shall have more to say about the system in a future number, when we shall be at liberty to publish details of the trials, which have already been made on a practical scale.

CULVERTS UNDER RIVERS AND CANALS.

From the "Mechanics' Magazine."

There is always more or less hazard and risk in disturbing what may be called the "existing state of things." Nevertheless, it becomes imperatively necessary, on certain occasions, to incur the risk of so doing. Of all the examples of engineering practice, in which a corroboration of this statement is to be found, that relating to interfering with the *status quo* of the beds and banks of rivers and canals, affords the most conclusive one. Numerous have been the accidents, and dire the consequences of excavating even in the approximate locality of these situations. It is impossible to observe too much caution in conducting operations of this nature, which have now become more frequent than formerly. This is partly owing to the fact that rivers are no longer regarded as inseparable barriers between their opposite shores, and that attention has, during the last few years, been prominently drawn to the practicability of effecting a communication underneath instead of overhead. This has been exemplified on a gigantic scale by the proposed submarine communication between England and France, and is being practically carried out by the Waterloo and Whitehall Pneumatic Company, and by the construction of the subway under the Thames at the Tower. Although not arrived at this pitch of subfluvial tunneling, the French have accomplished something in that line, by the large syphon tube recently successfully laid under the Seine, to connect the sewage channels on each side of that river. The laying of culverts and pipes under embankments has always been a source of anxiety and trouble to the engineer, even when the embankments are made at the same time. It is needless to point out how greatly the trouble increases, and how much greater need there is of precautionary measures, when the case involves the undermining of a bank already *in situ*.

There are two very prominent instances to be adduced where the laying of pipes and culverts underneath the banks of water reservoirs were attended with leakage and bursting. The one is the well known catastrophe at Bradfield, some few years ago. The other is the leakage and subsequent emptying of the Vartry reservoir, constituting a portion of the Dublin Water Works. Whatever might have been the true cause of the former mishap, whether it was due to an error in the principle of construction adopted, or in practical working defects, there is very little doubt about the latter. The extrados of the arch of the culvert was left nearly smooth, without any offsets, steps, or "racking back," to afford a firm hold of the puddle of the bank. In fact, there was really a straight joint between the puddle and the masonry, whereas there should have been a union as intimate as it was possible for ingenuity to imagine. As might be expected, the water found out the "weak spot." The result was the emptying of the reservoir, which had taken months to fill, and the plunging of the Dublin Corporation into litigation, which entailed upon it a large amount of expense. In many of the towns where new sewage works are in course of construction, it has been necessary to lay iron pipes below the beds of the adjoining rivers and canals, both for the purpose of effecting a communication between the sewers upon the opposite sides, and also, in some instances, to constitute a channel of conveyance for the sewage to the fields intended to be irrigated. This subaqueous plan has been adopted at Norwich, where very extensive drainage and sewage works are in progress. Some idea of their ex-

tent may be gained from the fact that they are estimated to cost £60,000. Provided the foundation be good, and concrete be used liberally, the only point presenting much difficulty is the joints, which sometimes give a great deal of trouble. The depth to which the drains must be sunk depend, in the first place, upon the levels; and, secondly, upon the condition of traffic in which the river is placed. If the river be navigable, and used for the purposes of navigation, the pipes should not be placed too near the surface, and should be well protected, especially about the joints, with cement concrete, or they are liable to be damaged by the anchors of boats. Were there any choice in the matter, it would always be preferable to take the drain or pipe over instead of under the river, but it is seldom that the levels are so entirely optional as to afford the right of selection.

An instance of the bursting of a canal embankment, in consequence of excavating underneath it, for the purpose of constructing a culvert, occurred a very short time ago. A portion of the embankment of the Napton and Warwick Canal was washed away, making a breach nearly 40 ft. in width.

As a rule, we should prefer in these hazardous situations to lay cast-iron pipes instead of building a culvert. The time which the disturbance and interference with the existing bank occupies is of equal importance with the nature of the operations carried on. A much shorter time will suffice to lay in a pipe than to construct a culvert of brickwork or masonry. The former will also require less excavation than the latter, for supposing them to have the same internal dimensions, the arch, invert, and side walls of the culvert, will necessitate the taking out of considerable additional quantity of earth. These proportions in a cast-iron pipe are simply its thickness, which practically is inappreciable. Besides, an increase in the capacity or internal size of the pipe, produces little or no corresponding difference in the thickness. With the exception of the difficulty sometimes experienced in making good the joints, there is no comparison with respect to the relative facilities of the two methods for establishing a speedy and secure communication between the opposite banks. The manner in which the canal is constructed, at the place where the intended pipe or culvert is to cross, has a very great effect upon the risk attending its successful laying. Should the canal be carried altogether in an embankment, and the levels not permit of the pipe being laid in the natural ground, but require it to be placed in the artificial bank, the danger is seriously augmented. Not only is the foundation more treacherous and insecure, but the earth above is more liable to subside than if it consisted of a thin stratum of the natural surface. Subsidence is not necessarily a forerunner of leakage or bursting, but it frequently does precede these serious contingencies, and may be regarded as a warning sign which should never be disregarded. A distinction must be drawn here between the ordinary subsidence, which invariably follows the erection of every new bank, a short time after its construction, and that for which there is no apparent cause. The former is always expected, and provision made accordingly for raising the bank to its proper level. The latter should be at once carefully inquired into, and a constant watch set on the spot.

IRON AND STEEL NOTES.

DURATION OF BLASTS.—A metallurgist who has spent the past winter in traveling among the French and English furnaces, gives it as his opinion that many of the recently-constructed and systematically managed establishments of the United States have nothing to fear from a comparison with the very best in Europe. In fact, there are some respects in which the ironmasters of this country are decidedly in advance of their trans-Atlantic compeers. The ever-increasing consciousness of the necessity of very high temperature in the blast is far more generally acknowledged and obeyed in this country than in Europe; and the average number of workmen required to perform the usual labor about the furnace is much greater there than here.

This observer gives the palm, among the works which he visited, to the furnace near Middleboro', in the Cleveland district. "Everything," says he, "is new, practical and neat, even to elegance."—Whether, however, in the colossal furnaces of that neighborhood the limits of economy have not been passed, is a serious question. The two furnaces at Rosedale are 103 feet high and 27 feet in the boshes. Certainly their production of eighty or ninety tons per twenty-four hours, great as it is, seems to be below the proportion of their vast dimensions.—Probably the use of the Lürman cinder-block, which has been adopted at some of the works, will be found especially advantageous in raising the product of very large furnaces, since it brings the slag discharged much nearer the center of heat, to say nothing of other favorable effects.

One point of difference between American and foreign blast furnaces is not in our favor. We are not able to keep as long in blast as do the Europeans. This complaint is quite general among us, and it is well worth while to inquire whether the difficulty arises from a defect in the quality of our

natural or manufactured fire-proof material. With a view to answer this question, careful experiments have been made abroad upon samples of American clay and bricks furnished by W. M. Lyon, Esq., of Pittsburgh, and the results have just been communicated to us by Mr. George Asmers, under whose direction they were instituted.

It was found that our Mount Savage fire brick excels the best varieties in Scotland, Germany or Belgium, and that our Star at least equals them.—A third brand of cheap American brick, the Porter, showed itself not sufficiently fire-proof to be used even in the upper parts of blast-furnaces. These experiments do not by any means prove that there are not many other kinds of American fire-brick as good as those mentioned. In fact, we have ourselves obtained and manufactured material from New Jersey which successfully resisted tests before which the famous Stourbridge brick gave way.—The question to be answered in these experiments was merely whether it would pay to import Scotch or German brick on the assumption that all American material is defective. This question is now clearly answered in the negative; and if Mount Savage or Star bricks do not hold out as long as Garnkerk, the reasons must be sought elsewhere than in the raw material. Most complaints of this kind come from furnaces which smelt the very rich ores of Lake Superior, and that, too, with extremely small additions of lime. Under these circumstances, the formation of cinder at the expense of the alumina of the fire-brick is inevitable. The evil is aggravated when the blast is not so strong; as, for instance, at the charcoal furnaces of Lake Superior, when the pressure is but one and a half pounds. The zone of fusion here becomes annular, and hugs the walls, producing such a rapid action upon them that it is not surprising that the blasts in that neighborhood seldom last longer than twelve or fifteen months.

Careful experiments only can determine whether it would be wise to change the present proportion of flux and the pressure of blast to gain the advantage of longer campaigns. Such question cannot be flippantly answered *a priori*. One thing, however, is now certain. We do not need to look for better material in the construction of furnaces than our own country affords.

[The above is from the "Journal of Mining."—The "American Exchange and Review" makes the following comments:]

In addition to the above, it may be said that there is as singular a variation in the endurance of English furnaces as there is in furnaces in this country, in districts where the ores vary. We speak now in respect of the endurance of the furnace ring or inner walls. The gentleman last named is upon the line leading directly to the cause of difference between the endurance of American and of European furnaces. The peculiarity of ores demands a peculiarity in fluxing, and if that type or normal condition is not reached in the charge thrown into the furnace, the silex and alumina, not the alumina alone, must suffer, and the brick is dissolved or fluxed in itself. The nature of the ores reduced, therefore, has much to do in bringing about the difference in endurance. This may be considered a probable suggestion when we notice the large amount of lime in the charges of English furnaces as given in the type cinder of Dr. Percy, namely, 38 silex, 15 alumina, 47 lime; whereas in the large majority of our American furnaces 30 of lime would be the maximum.

EXPERIMENTS AT THE JOINT EXPENSE OF IRONMASTERS.—The Staffordshire correspondent of "The Engineer," says: Amongst some of the most advanced producers of pig and finished iron in this district, there has for some time been a desire that such a combination should exist that experimental works may be carried on at the cost of a joint purse and for the benefit of all, such as machine puddling, and other suggested improvements in the mill and forge department.

The same idea is now finding expression in respect of the making of pig iron. A South Staffordshire ironmaster, who within the last six years has made five visits to the Cleveland district, bases upon what is being done there an appeal to the trade in his district, to devise some machinery by which they may at one cost try each separate experiment, and to learn what would prove most valuable for permanent adoption. "During my first visit, I saw (he says) furnaces in advance of any then in Staffordshire; since then, at some of the works, those furnaces have been altered once or twice, and are now either rebuilt, or are about to be." Indeed one of the Cleveland ironmasters himself remarked to me, in consequence of my having said that I had thought, the first time I was in the district, that the furnaces were so perfect they would probably remain for years unaltered: "In the last six years I have built five furnaces, each in advance of the other; I have now pulled them all down and rebuilt, or am about to rebuild them as 85 ft. furnaces, with 27 ft. boshes, capable of making 450 tons of iron per week."

The South Staffordshire master remarks: "This seems a very lavish way of laying out money, but let us examine it more closely. To rebuild a furnace would probably cost somewhere about £1,000, but if by rebuilding you can save 1s. per ton on say 200 tons per week it would amount to £520 saved per year, or upwards of 50 per cent on the outlay." Now, as their furnaces make up to 450 tons per week, it is evident that they are wise to alter where they can see a saving of anything like 1s. per ton. What we want is a system of trying every new plan on one given furnace, and under the same circumstances, and in such a way as to obtain perfectly reliable data, such data to be open to all subscribers. This could be best done by forming a Blast-Furnace Institute, each member subscribing so much per furnace, according to the number of furnaces that he owned or leased. Such an institute would have a working committee, who would build or engage one or more furnaces, as well as a manager, and keep all accounts on the cost-book system, showing each separate account. The committee should meet at least once a month, and individually make frequent visits to the trial furnace. Say they are working a 50 ft. furnace, and at the first meeting agree to try the proper working height of furnaces with the different coals of the district. The furnace would be burthened to its very outside working powers at that height, with each of the coals to be tried, strict returns of the yields of everything being kept. These being finished, let the furnace be raised 5 ft., and then try them all again. Should any or all of them prove to work to better advantage at the increased height, then raise another 5 ft., and go on in the same way till that experiment was

exhausted. We might then try increased heat of blast, or a close hearth, and then the yield of any one or all ironstones by themselves. The value of such an institute no one can tell, but supposing that by trying heights we saved as much as five cwt. of coal to the ton of iron—in Shropshire they save seven cwt., and in Cleveland upwards of ten cwt.—it would be somewhere near equal to adding one-seventh to the life of Staffordshire, whilst it would improve the quality also.

NEW BLAST ENGINE.—A blast-furnace engine built at Norwalk, Conn., and described in the the "American Exchange and Review," has the following peculiarities: It is a vertical engine.—The air cylinder is 72-in. diameter and 8-feet stroke; the steam cylinder 36-in. diameter. The air piston and follower, instead of being cast iron and having packing between, consist of a ring six inches in thickness, with space for packing, which will be of solid wool felted and set out by a spring ring. Instead of the one piston rod taking the piston in the center, there will be three taking hold of the outside of the air piston, passing up through the head *outside of the steam cylinder*, and fastened to the crosshead. The great advantage of this is that it entirely prevents any steam or water from being carried down the piston rod through the stuffing box into the air cylinder. The air piston being simply a ring held by the three rods, and the entire center being covered with boiler iron slightly concaved, is very light. The steam piston is cushioned at both ends by passing and closing the exhaust ports just before the termination of the stroke, thus rendering striking the heads absolutely impossible, besides making the change of stroke almost instantaneous, and in consequence of this the variation of the blast is little or nothing.

THE LARGE BLAST-FURNACE AT NORTON, ENGLAND.—We have received, says the "American Exchange and Review," the following description of the blast-furnace at Norton, near Stockton-on-Tees, England, erected by John Player, of Player & Henderson, 30 Broadway, New York. It is 85 feet high, and 25 feet across the boshes; cubic contents 26,000 feet; and closed top, or bell and hopper arrangement for charging; has one horizontal blast engine, blowing cylinder seven feet diameter by seven feet stroke, working twenty-two revolutions per minute; has four of Player's patent hot-blast stoves, of thirty pipes each: heating the blast 1,000° to 1,200° Fahr., pressure of three and a half to four and a half pounds on the square inch, using six *tuyères*. It was blown in March, 1867, and in 1868 produced 25,327 tons of pig iron; and in February, 1869, was producing about 600 tons of foundry iron per week. The consumption of fuel is about one ton to the ton of pig iron. The ores are now 42 per cent, yielding two per cent better than with smaller furnaces. Less goes into the slag, or cinder, than formerly with the small furnaces. The fuel is ordinary coke that could not be worked in small furnaces, owing to its injurious effect on the quality of the iron.

The gas arrangements, or rather the arrangements for drawing it off, are so perfectly constructed that the supply is divided up into sixteen different jets, or flues, so that each stove and boiler has its supply independent of the other, and there is enough for steam and for heating the blast; it is regulated and consumed with the same facility that ordinary lighting gas is consumed in a dwelling, and is consumed on the principle embraced in an Argand burner, by a gas regulator.

The production of this furnace has exceeded the anticipations of the parties concerned by fully fifty per cent. It is illustrated in "Engineering" (August 10, 1866, p. 104), where it is stated that it was expected to produce 400 tons per week, while it now produces about 600 tons. It is expected that it will keep in blast five to six years longer, or seven to nine years in all. Owing to the time that it will probably remain in blast, the expenses of repairs will be less than in any other furnace, per ton of iron. There are no repairs to be charged to the hot-blast stoves, nor will there be, as, owing to the principles of their construction, none can be required. The labor account of this furnace is but a trifle in excess of that of one of eighteen feet, whilst the product is double.

Estimate of cost of this furnace at present wages and prices of materials, to include furnace, casting house, engine house, lift stoves, etc., complete to take the blast:

Foundations,	$5,300
Common bricklayers' work,	24,800
Fire bricklayers' work,	37,500
Cast-iron work,	25,000
Blast engine,	13,000
Boilers, etc.,	6,500
Pumps,	2,500
Machinery for hoisting,	3,500
Sheet-iron work,	4,000
Wrought-iron bands,	3,000
Valves, pipes, cocks, stays, etc.,	5,500
Various expenses, such as fitting, setting engines, boilers, scaffolding, extra labor,	15,000
	$145,600

We would modify this communication from Mr. Henderson by simply stating that we are under the impression that his estimates of cost of producing iron on the Lehigh are too low as to coal, limestone, and in some places in ore. The cost of limestone is about $1.75 in some places, of coal more than twice as much, even before the strike, and ore (brown hematite) is generally from $5 to $5.20 at the mines, to say nothing of the magnetic ore which forms nearly, and in some places quite, one-quarter of the charge, and is much more expensive. With what has been said in a previous article in the present number of the "Exchange and Review," our readers can draw their inferences as to the comparative excellence of small and large furnaces.

MIXING IRON ORES AND CHARGES.—Dr. Crookes, in his new work upon iron, just received, has the following concerning the mixing of ores and charges:

1. Rich ores without earthy substances. They are mixed either with poor ores or with fluxes of blast-furnace slags, neutral silicates, etc.

2. Silicious ores. These are the most common; they are mixed with different fluxes, according to the state in which the silica is associated with the the ore, viz:

a. Silica is mechanically admixed with the ore, ores generally difficult to fuse, requiring aluminous and calcareous fluxes; best in the form of aluminous lime if suitable iron ores are not obtainable.—

Fluor spar has some advantages over common lime, as its fluorine volatilizes part of the silicon. It fuses easily with heavy spar, gypsum, and phosphate of lime, and is therefore a good flux for ores containing those substances. Ores at the same time containing quartz in a finely disseminated state and protoxide of iron are difficult to smelt. The silicious ores without manganese produce gray or mottled iron.

b. The silica is more or less saturated by other bases than iron. The silica is sometimes saturated with bases in such a manner as forms a suitable slag without the addition of other fluxes; or when contained in richer ores, an addition of neutral fluxes is required only to produce the sufficient quantity of slag. In most cases, however, the silica is not sufficiently saturated, and it then requires an addition of basic minerals, calcareous ores, or lime. In rare cases ores are smelted containing silicates so basic as to require an addition of silica or aluminous marl, etc.

c. The silica is combined with peroxide or protoxide of iron, as in puddling, refinery slags, etc.—These substances are difficult to smelt, and the best method is Lang & Frey's, according to which 25 parts of well burned fresh lime are slaked, and mixed while warm with 65 parts of pulverized slag and 10 parts of pulverized coal. The mixture is molded into forms, dried, and broken up to the size usual for smelting.

3. Calcareous iron ores being very refractory when smelted by themselves, are mixed with argillaceous iron ores or clayey substances. Pure quartz is seldom employed as an addition, for it requires a longer time for the formation of silicates, and is liable to scorify protoxide of iron.

4. Iron ores containing magnesia are very refractory, and require an addition of argillaceous substances and lime. If these ores contain at the same time a certain amount of manganese, the reaction of the magnesia will be partly neutralized.

5. Manganiferous iron ores sometimes smelt by themselves and are inclined to yield white pig iron, but they usually require an addition of lime in order to produce a slag free from iron. An increased addition of lime or magnesiferous substances is required if the production of gray iron is intended from these easily-fusible ores. Easily-fusible ores poor in manganese, such as some sorts of black-band, also require a greater addition of calcareous fluxes.

6. Titaniferous iron ores, usually difficult to fuse, require fluxes of lime and quartz. Alkaline fluxes are also very effective.

PLATING STEEL, ETC., WITH NICKEL.—There were recently exhibited before the Polytechnic Association of the American Institute, several specimens of iron and steel, upon which nickel had been deposited by the battery by a process devised by Dr. Isaac Adams, of Boston. It was claimed for this process, that while nickel is a much cheaper metal than silver, it is much harder, and is not affected by atmospheric influences, while at the same time the color is nearly equal to that of silver. Nickel is admirably adapted to the engraver's purposes, as from its extreme hardness, a plate of nickel will outwear several plates of copper. Hitherto it has been found impossible to deposit nickel to a greater thickness than that of a mere film. The mere deposition of nickel on steel is nothing new. Directions for the process will be found in Smee's work, published many years ago. But thus far it has been found impossible to deposit nickel in thick plates, for as soon as a film has been thrown down, the nickel is deposited in the form known as the "black deposit," which is friable and worthless.—Hitherto it has been thought necessary to use pure nickel for the pole or anode that is to be dissolved, but Dr. Adams has succeeded, even when the metal employed did not contain more than 75 per cent of nickel. Mr. Smith did not describe the process employed, as he stated that he was afraid his memory was not to be trusted in regard to it. The solution employed is the double sulphate of nickel and ammonia, but it must be prepared in a special manner, in order to insure success.

THE CLOSED HEARTH IN BLAST-FURNACES.—The correspondence of the "Engineer" thus mentions the use of this improvement in Cleveland:—The devices of the Cleveland iron-masters to stop all leakages or droppings, and to husband and economize all available products, are notorious. Nor are the other districts, so far as it is possible in the localities of old date, supine. The closed hearth system of working blast-furnaces, which has been applied to some forty furnaces in Prussia, is now being tried, we see, in Shropshire. By this system the hearth is kept much hotter than by the usual method, for there is no waste of heat to keep up the temperature in the useless channel between the hearth and the dam. Instead of blowing into the cinder, as in most of the English furnaces, the *tuyères*, upon Lürman's patent, are inserted on a level of about nine inches above the scoria outlet, thus bringing the full force of the blast upon the materials. Fuel is saved, and more iron, and of a better quality, is produced. The casting may be carried on without the blast being taken off, which is another source of economy, and the "blowing through" process after every cast, with its consequent waste of heat, is unnecessary. There is reason to conclude that the furnaces will not display a tendency to "bridge up," that condition of things being prevented by the intense heat, by which everything becomes thoroughly melted. So far as the experiments have already gone, the patent can be applied where tender as well as strong fuel is used.

THE SIEMENS-MARTIN PROCESS IN ENGLAND.—The North Yorkshire Steel and Iron Company, amongst whom Mr. Bernard Samuelson, the member for Banbury, is a conspicuous proprietor, have attempted to carry out the Siemens (Martin's) process for the manufacture of steel; but after much experimenting have, in reference, certainly, to some of the stages, abandoned the project, to the consequent great regret not alone of themselves, but likewise of the people of Newport, where numerous work-people began to find employment in a new avocation, but are now being discharged. The attempt is not, however, to be definitely given up. —*Cor. Engineer.*

NEW HEATON PATENT.—The invention of Mr. John Heaton, of Langley Mills, Derby, just specified, relates to improvements in the manufacture and production of iron and steel, and consists in the employment of the cinder or slag resulting frem the balling of steel or of steely iron which has been obtained by the action of nitrate of soda or of nitrate of potash upon cast-iron, either in a converting

vessel or apparatus such as is described in the specifications of letters patent granted to him (Nos. 798 and 1,295), or in any other suitable furnace or apparatus. This cinder or slag he employs either in what is known as the puddling process for the production of malleable iron, or of steel from cast-iron, or in the blast-furnace, for the purpose of improving the quality of cast or pig iron to be produced. In the employment of the product obtained by heating together oxide of iron and carbonate of soda, or caustic soda, or mixtures of the same for the production of malleable iron or steel from cast-iron, in what is known as the puddling process, and also its employment in the blast-furnace, for the purpose of improving the quality of cast or pig-iron to be produced.

PUNCHED STEEL AND IRON TUBES.—It is upwards of two years since we first publicly drew attention to the interesting process of making tubes by punching a solid ingot, and gradually enlarging it afterwards by punches of successively increasing diameter, so as to put the work upon the tube from the inside instead of, as heretofore, longitudinally. Messrs. Deaken & Johnson's punched tubes have since achieved a great commercial success. Upwards of a quarter of a millton have been made, and in many large contracts abroad, especially for the Remington rifles, no others are used.—*Engineering.*

TESTING MACHINE.—A writer in "Engineering," remarks that in some tests which he witnessed with the Kirkaldy machine, a trammel used on the bar itself, showed a far less amount of extension under various strains, than was indicated by elaborate machinery and index attached to the instrument for this purpose. This is an important point to have in view in connection with such tests.

THE pig-iron product of Great Britain in 1868 was 4,800,000 tons, that of the United States 1,603,000 tons.

ORDNANCE AND NAVAL NOTES.

EUROPEAN SMALL ARMS.—With regard to small arms, the most prominent feature of the year has been a continuation of the activity to which the events of 1866 gave the first impulse. In the North German army, the work of arming the troops with the well-tried needle-gun was pushed vigorously forward. For the fortresses, rifled percussion-guns of home and foreign construction (Austrian, &c., taken in war) were transformed into breech-loaders. It is proved, by the result of trials made at the military practice school in Spandau, with guns of the most approved systems, that the needle-gun, in precision and rapidity of fire, is inferior to none. On the other hand, the superiority of the small caliber, under some circumstances, is a matter that merits serious consideration. Hesse, Baden and Wurtemberg have armed their contingents with the needle-gun. Bavaria will not remain satisfied with the Podewils gun transformed on Lindner's system, and will probably adopt that of Werder. Austria has not yet completed the transformation of her old rifles according to the system of Wanzl. The model of Werndl presented some difficulties of construction, but the manufacture is now said to be going orwards. Here, as everywhere, it is the metal cartridge that has caused the trouble. Since April, the French infantry have been armed with Chassepots; but this is only the case with the army on its peace footing. Although private industry abroad and at home has been had in requisition, a sufficient number of these arms has not been procured for the army when in war, not to mention the reserves. Liège supplied 40,000 last year, and hopes to finish 80,000 in 1869. In spite of some defects, which the Minister of War himself acknowledges, the weapon seems, on the whole, to give satisfaction.

For the National Guard, the old rifles are being altered according to Snider. Italy and Russia have adopted the needle-gun. The Italian rifle pretty closely resembles the Dorsch and Baumgarten construction. In Russia the change progresses very slowly, and the breech-loaders, altered after the model of Carlé, are, according to the latest news, only in the hands of the guard. Berdan is contemplated as a new model, and of these 50,000 are said to be in readiness. Only the North German Confederation, with Baden and Wurtemburg, is at present completely supplied with breech-loaders, and then come France and England. All the other States are more or less behindhand in this respect. At present the needle-system preponderates, as four great States and several of the smaller have adopted it.—*Kreutz Zeitung.*

THE MONITOR SYSTEM GAINING GROUND.—A British captain recently said: "For nineteen years we had to deal with vessels which we knew were worthless to fight in. They were gorgeous in appearance, rich in tradition, associated in the past with all our naval glories, and it is a bitter thing to part with them; but, still, that old wooden fleet has been at last got rid of, for last night the First Lord of the Admiralty promised you that even your reserve in future should be an iron-clad fleet. Having got rid of that wooden fleet you have now to prepare yourselves in the next ten years, if you are governed and led as you should be, to find the fleet trusting to steam machinery alone for its progress."

Whereupon the "Army and Navy Gazette" remarks: "Until Americans and French, Prussians and Russians decide upon ceasing to build ironclads, casting and building up 20-ton guns, rifling and smooth-boring and manufacturing other implements for the ready and wholesale destruction of human life, we cannot afford to be behindhand; and so we fear the ugly, low, iron floating citadels must drive from the face of the waters the stately three-decker. War is a business, sad as it may be, and those who engage in it cannot indulge in a sentiment which might lead to bankruptcy. We must make up our minds to fight when called upon behind twelve or fifteen inches of iron armor-plates, and our movements regulated by steam power representing the combined strength of nine or ten thousand horses."

When the British navy comes down from three-deckers to "ugly, low citadels," protected by twelve or fifteen inches of iron," and propelled by "steam machinery alone," it will be a splendid realization of the *American idea*, first proposed by Stevens and made practical by Ericsson.

COMPARATIVE EFFICIENCY OF THE NEW BRITISH GUN.—A 9-in. Frazer gun, made for an endurance trial—a trial *à l'outrance*—has withstood upwards of 1,100 discharges, and of these 400 were full service rounds of 30 lbs., with 250 lbs. rifled

shot, while the remainder were battering charges of 43 lbs., with the same shot. The gun is scarcely enlarged in the chamber, the rifling hardly worn.—It is a reason for just national pride, or, rather, for an even greater pride. No Krupp gun of large bore could be adopted with confidence in our naval service. No French gun could hold its own for an hour against such a test. As for the American guns—the huge smooth bores—they have been officially condemned and abandoned by the ordnance engineers of the cousin country.—*Engineering.*

We are greatly indebted to cousin Bull for working out the Fraser gun—at a fabulous cost. When it is quite perfected we shall adopt it in places to which it is suited. Meanwhile we are equally thankful to cousin Bull for disbelieving in the Rodman XV inch. It answers very well our modest requirements—such as enduring the thousand test rounds, firing hundred pound charges, and smashing such targets as it has been aimed at. The late Congressional ordnance committee, referred to by our cotemporary as the "ordnance engineers" of America, have, indeed, abandoned the Rodman, but as long as it is retained and believed in by the army and navy it will meet our wants till the Fraser and the Woolwich machinery are so far perfected that they can be safely copied.

FRENCH MERCHANT MARINE.—The following results relating to the mercantile marine of France are taken from the general table of the foreign commerce of France just published by the Minister of Agriculture, Commerce, etc. On the 31st December, 1867, the total tonnage was 1,042,751, and at present is 1,048,679, showing an increase of 5,,928 tons. The number of vessels is 15,602. Of these, 7,212 are below 10 tons; 4,757 from 10 to 100; 2,733 from 100 to 300; whilst above 800 there are only 76. Out of that total 215 are steamers representing 86,102 tons, an augmentation being found over the previous year of 8 ships and 11,192 tons. These figures are of great interest, as they show the constant advance of constructions intended to accelerate navigation. The port of Marseilles has the largest share—viz., 172,829 tons distributed amongst 792 vessels. Havre comes next with 132,296 and 390; Bordeaux, 129,167 and 413; Nantes, 114,734 and 647. Bordeaux has the greatest number of large vessels—283, from 100 to 800 tons. The difference between the entry and departure in ballast is considerable. In 1867 the tonnage was 19,000 for the former and 2,505,000 for the latter. The figures for loaded vessels are 6,366,000 and 4,125,000 respectively. The result is that France has always great difficulty in finding export freights.—*Army and Navy Gazette.*

CONSTRUCTION OF ARMOR PLATE.—Two armor plates, each 5 in. thick, manufactured by Cammell & Co., for the Austrian government, were recently tested by four shots from the 8-in. smooth bore at 30 ft. range. The one plate was made in the ordinary way, the other was made up of three thicknesses, by placing an armor plate 4¼ in. thick between two thinner plates, and rolling them down to the required thickness of 5 in. It was remarkable to see how closely the one plate resembled the other after the tests had been made, the greatest indents being 2.5 in. and 2.4 in. respectively, while the bulge in the back in both instances were 3¼ in. over an area of 2 ft. 3 in. and 2 ft. 4 in. respectively. It was clearly established that there was practically no difference in the merits of either plate, and both will receive a high classification.

The above is from an engineering and metallurgical journal of high authority, which fact prompts us to ask if all rolled armor plates are not made from piles of thinner plates, rolled down to the required thickness. We should think a difference rather than a resemblance in the results mentioned—the iron being the same—would have been remarkable.

THE RUSSIAN FLEET.—The following are the particulars of the Russian fleet, as given in the "Journal of St. Petersburgh," from the report of the Ministry of the Marine: On the 1st of January, 1869, the fleet counted 230 steamers and 37 sailing vessels. The former consisted of the following armor-plated vessels: 4 frigates, 3 batteries and 13 monitors. Non-plated vessels: 6 ships of the line, 8 frigates, 18 corvettes, 7 clippers, 62 gunboats, 6 vessels colled "vapeurs-frigates," 4 imperial yachts, 13 schooners, 22 transports, 48 despatch boats, and 16 chaloupes. The sailing vessels consisted of 5 yachts, 4 schooners, 15 transports and 13 chaloupes. Of these 156 vessels were in the Baltic, 1 in the White Sea, 30 in the Caspian, 41 in the Black Sea, 31 on the eastern coasts of Siberia, and 22 in the sea of Ural. There were, in addition, 4 plated frigates and a steam yacht on the stocks in the Baltic, and 2 gunboats on the Siberian coast.

BRIDGE BUILDING IN WAR TIME.—Bridge building was one of the arts brought to the greatest state of perfection during the rebellion. General McCallum states that the Rappahannock River bridge, 625 feet long and 35 feet high, was rebuilt in nineteen working hours; Potomac Creek bridge, 414 feet long and 82 feet high, in forty working hours; Chattahoochee bridge, 780 feet long and 92 feet high, in four and a half days; that between Tunnel Hill and Resaca, 25 miles of permanent way, and 230 feet of bridges, were constructed in seven and a half days; and near Big Shanty, 35½ miles of permanent way, and 455 feet of bridges, in thirteen days.

TRIAL OF ENGLISH AND FRENCH RIFLES.—The current number of the "Proceedings of the Royal Artillery Institution" contains an interesting account of a trial lately, at Woolwich, of the Chassepot rifle in comparison with the Henry-Martini. As regards accuracy, it appears that the Chassepot was greatly inferior to the English arm. The worst target made with the Henry-Martini at 500 yards was 1.652 ft., the best with the Chassepot was 2.38 ft. The best target with the Henry-Martini showed a still higher degree of accuracy. viz: .96 ft. The trajectory of the Henry-Martini was flatter than that of the Chassepot, viz., 8 ft. 2 in. against 10 ft. In simplicity of manipulation the English rifle was superior, and it is less fatiguing to use. In firing for rapidity the Chassepot gave 20 rounds in 1 min 42 sec.; the Henry-Martini 20 rounds in 48 sec., or more than twice the rapidity.

NEW TURKISH IRON-CLAD.—The Moyini-Zaffer, built for the Turkish government by Messrs. Samuda Brothers, at Poplar, was recently launched. The length is 230 ft., breadth 35 ft., depth 27 ft. Her burden is 1,400 tons, and her displacement 2,400 tons. Her armament will be four 12-

ton rifled guns placed in a double central battery, so arranged that they can all be fired on one broadside, or can be trained to fire in a line nearly parallel with the ship's course as bow and stern chasers. She is designed by Mr. Markrow, of the Thames Iron Shipbuilding Company, and will, if the expectation of her designer and builders be accomplished, be the fastest vessel of her class afloat.

NEW BOOKS.

IRON AND STEEL MANUFACTURE: A SERIES OF PAPERS ON THE MANUFACTURE AND PROPERTIES OF IRON AND STEEL; WITH REPORTS ON IRON AND STEEL IN THE PARIS EXHIBITION OF 1867; REVIEWS OF THE STATE AND PROGRESS OF THE MANUFACTURE DURING THE YEARS 1867 AND 1868; AND DESCRIPTIONS OF MANY OF THE PRINCIPAL IRON AND STEEL WORKS IN GREAT BRITAIN, THE CONTINENT OF EUROPE, AND THE UNITED STATES. By FERDINAND KOHN, C. E. New York: Virtue & Yorston, No. 12 Dey street; and D. Van Nostrand.

This handsome volume, which is profusely illustrated, embraces a series of paper on the manufacture of iron and steel; reports on iron and steel in the late Paris Exhibition; reviews of the state and progress of the iron and steel manufacture in 1867 and 1868; together with detailed descriptions of the principal iron and steel works in Great Britain and on the Continent. . . . The author commences with a general notice of the iron aad steel manufacture in 1867, and in this the method of arrangement adopted in the body of the work is indicated. The first important division is devoted to iron smelting. This introduces much useful information about the Scotch iron field, particularly of the Gartsherrie, Coltness, Govan, and Langloan iron works. Barrow-in-Furness naturally comes in a prominent place, and the extensive works at Wigan are also described. The new district of Cleveland receives, as might be expected, an elaborate notice, the more modern furnaces being fully explained by illustrations. About one-half of this division is appropriated to continental iron works, and to various metallurgical subjects connected with the manufacture of pig iron. The engineering appliances required for blast furnaces—such as hoists, blowing engines, calcining stoves, &c.—come next in review, all the newest arrangements being fully described. A considerable space is devoted to cupolas, foundry cranes, and foundry work in general; the Phœnix Foundry, Glasgow, and the Ormesby Foundry, Middlesborough, being especially noticed. The production of Bessemer steel takes up a great part of the work. Very elaborate details are given of the plant required in carrying on the Bessemer process. Descriptions of the Cyclops Steel Works, Sheffield, of the Barrow, Dowlais, Don, Gorton, Mersey, and other steel works, appear with elaborate illustrations of the most improved arrangement of Bessemer plant. The Siemens-Martin process, now being successfully introduced in this country, is noticed; also half a dozen other processes for the manufacture of steel. The important regenerative furnaces of Mr. Siemens, which are calculated to effect a great economy in the amount of fuel required in heating and smelting furnaces, are naturally described in detail, more particularly as applied in several places to puddling purposes. Coming to the manufacture of wrought iron, we find articles on puddling, including the various attempts that have been made to carry on the process by mechanical means; followed by descriptions of forge hammers, forging presses, and rolling mills. In the latter department, tyre rolling, the universal mill, improved plate mill machinery and adjuncts, form a highly important feature in the volume. If we add that reports on the iron and steel exhibited at Paris, and on various matters connected with the strength and elasticity of iron and steel, are appended to those above enumerated, we have given a tolerably clear sketch of what Mr. Kohn has collected in this quarto volume of 288 pages, with its 83 full page illustrations. . . . The book will, assuredly, be of good service to the trade, particularly those who are practically connected with iron or steel works; and we have no doubt it will have an extensive circulation in all the iron-making districts. —*Iron and Coal Trades Review.*

THE MINING ATLAS. By THOMAS SPARGO, M. E., &c. Published by the author, at 224 and 225, Gresham House, Old Broad street, City. For sale by Van Nostrand, New York.

Mr. Spargo has in the present work excelled all his other publications, by the importance of the subjects and the exceedingly interesting manner in which they are treated. No fairy tale could contain a more romantic air, or be written in a more graceful style, than the "Mining Atlas." So varied is the geological, mineralogical, topographical, and geographical information and description that the work is a repertory of scientific information, associated with scenes and incidents, local and historical, of thrilling interest. All the maps and sections are beautifully executed, but that of Colorado territory is a surpassing beautiful specimen of orographical delineation. The literary portion of this number is varied and excellent. Chapter I is introductory and general; chapter II, how mines are worked, and plans and sections are framed; chapter III, general descriptions of the mining regions in Great Britain, of which maps and plans are given in the volume, such as Cornwall and Devon, Cardiganshire, and the Isle of Man; chapter IV, mineral-bearing regions of the American continent, Cardiganshire, Dolcoath Mine, and Botallack Mine. There are 36 quarto pages of literary description and original treatise on the important subjects above named. We strongly recommend not only persons engaged in mining as investors or otherwise, but the whole public to make the opportunity available of procuring what we do not hesitate to pronounce one of the most interesting works given to the public for many years. —*Mining Journal.*

CYCLOPÆDIC SCIENCE SIMPLIFIED. By J. H. PEPPER, Professor of Chemistry, F. C. S., A. I. C. E., &c. London: F. Warne & Co., Bedford street, Convent Garden. New York: Scribner, Walford & Co., 1869.

Professor Pepper is already known as a writer upon natural philosophy, but his earlier works were written for the youthful student. The volume now before us is an advance upon those, and conveys scientific information to such readers as may have neither the time nor the inclination to study the more recondite authors in such a form as is at once instructive and interesting. In fact, our author

transports himself, with all his happy ideas and illustrations, from the lecture theatre to a volume containing nearly 700 pages of letterpress, interspersed with about 600 engravings. The subjects treated of embrace light, heat, electricity, magnetism, pneumatics, acoustics, and chemistry, which are considered in all their varied branches, their practical applications being illustrated. The various natural phenomena are explained with brevity and simplicity, and illustrations are given, by means of which the general reader is at once made familiar with facts and principles, which otherwise would be but "dark sayings" to him. The author introduces here and there portions of papers, by our veterans of science upon the subjects of which he treats. Thus, among others, we find the names of Faraday, Daniell, Wheatstone, Brewster, Tyndall, Crookes, Siemens, Noad, Spillar, &c., whose writings are judiciously quoted in their own words, and are not hashed into a jumble by the pen of a plagiarist. In this work the reader will find reproduced many of those interesting experiments illustrative of the peculiar properties of light, heat, and sound, with which Professor Pepper has been wont to entertain them. In short, as a first progressive book in natural philosophy, and as one eminently calculated to stimulate the reader to a deeper research into scientific truths, we know of none which commends itself so well as Professor Pepper's "Cyclopædic Science Simplified." It is, moreover, a handsomely got-up volume, and does credit to the publishers, who have made the outside of the work as attractive as the Professor has made the inside.—*Mechanics' Magazine.*

LINK AND VALVE MOTIONS. By WM. S. AUCHINCLOSS. New York, 23 Murray street. D. Van Nostrand. [Second notice.]

There are few draughtsmen who are willing to bestow much time on the perusal of books on valve motions, or to give attention to rules for their design. The feeling is well nigh universal that the proportions of the parts can be determined with greater confidence on the part of the designer and with at least equal speed by the usual process of laying out the motion on the drawing board, as by reference to any rules intended to supersede this labor. The work before us, so far as it relates to simple eccentric valve motions, differs from the ordinary run of works of this class in that it does not propose a series of rules liable to be forgotten or misunderstood, but simply shows how the labor usually expended in laying down a proposed motion may be dispensed with and the results arrived at in the absence of all drawing tools. This is done by simple measurement on an engraved diagram which the author has constructed, and which, from its simplicity and convenience, excites wonder that it has not been used before. By means of this the designer can, in less than a single minute, tell what proportions of valve and position of eccentric must be employed to give a desired point of cut off with any length of connecting rod; or can in like manner determine any of the features of the valve motion when the necessary data are given without recourse to any geometrical construction or the study of any rules. In laying out the link motion the conditions are more complex, and here it is necessary to resort to geometrical construction, but the author shows the effect of the different modifications that may be made so clearly that much of the difficulty which, to many, appears inevitably connected with the design of a successful motion of this class, is removed.

The work is plentifully supplied with such tables as are required in the operation of designing valve gear, the effort of the author throughout being to lessen the labor of the designer by performing for him all the preliminary and incidental calculations which arise in such work, leaving him simply to select what is applicable to the particular case in hand. We feel sure that all who read the work will be struck at once with its practical value. S.

THE SMOKE NUISANCE AND ITS REMEDY BY MEANS OF WATER, WITH REMARKS ON LIQUID FUEL. By C. J. RICHARDSON, Architect. Atchley & Co., Great Russell street, Bedford square, London. W. C. For sale by Van Nostrand.

Mr. Richardson's plan for remedying the smoke nuisance is by washing it with the spray of water. He gives it in detail, with diagrams; and he remarks that though it certainly is not possible to disturb the whole of the chimneys of London, the worst of them might be operated on, such as the chief kitchen flues of the great establishments which are continually sending out inky smoke. If it were possible, as he observes, to cut into all the chimneys of London and apply the remedy, the whole of the soot which at present escapes into the atmosphere might be caught and passed into the drains: it would there deodorize them, and the sewage would be rendered doubly valuable as manure, and be largely increased in quantity. This would certainly be the best mode of remedying not only the smoke nuisance, but the sewage emanations also, because so long as the air is contaminated with these, the smoke is at least useful in the air as a deodorizer of them, however injurious to human lungs in itself, or unsightly in its effects on buildings. In the pamphlet under notice, Mr. Richardson gives the results of his important experiments with liquid fuel. The substitution of petroleum for bulky coal in steamers would be an immense improvement, both in our mercantile and our naval shipping. Mr. Richardson says that "any boiler having water space below grate can be fitted to burn oil, so as to obtain a result from 2¼ to 3 times above that given by the best coal; 5 times, probably, of that given by common coal: no alteration will be required, only some additional plates in lieu of fire-bars."—*Builder.*

THE HANDBOOK OF IRON SHIPBUILDING. By THOMAS SMITH, M. I. N. A. London: E. & F. N. Spon. For sale by D. Van Nostrand, New York.

We have here a handy little manual, consisting of but sixty-two octavo pages, yet containing within that space a greater amount of useful practical information than is to be found in many works five or six times its size. Mr. Smith states in his preface that his book is intended to serve as a practical guide to shipowners, shipbuilders, inspectors, shipmasters, foremen, and intelligent working men; and it appears to us that it is well calculated to fulfill its end. It contains no elaborate theoretical disquisitions, and, in fact does not deal with theory at all; but contains abundant practical information as to the points to which attention should be paid in constructing an iron vessel. The book is divided into two parts, of which the first consists of practical instructions, while the second contains a variety of useful information, such as the weights of deck-

beams, angle iron, plates and rivets, copper bolts, &c., the weight and strength of canvas, the allowances for waste in converting timber for shipbuilding purposes, and a large collection of detailed piecework and other labor prices.

The labor prices form an important feature in the work; they include the standard wages of the various classes of mechanics employed in a shipyard on the Thames, Mersey, Wear and Tyne, and the Clyde; and, as we have said, an extensive collection of the various piecework prices paid in the different districts. To these are added detailed tables of the actual costs for labor and materials of several iron steamers and sailing vessels of various sizes and classes.—*Engineering.*

APPLETON'S CYCLOPÆDIA OF DRAWING. Designed as a Text-Book for the Mechanic, Architect, Engineer, and Surveyor. Part I. Edited by W. E. WORTHEN, New York. D. Appleton & Co., 90, 92 and 94 Grand Street.

The system of publishing valuable books in parts by subscription has long found favor with mechanics and others, and very properly so. The present work, when completed, in thirty parts, at thirty cents each, will cost, including binding, not less than $10.50 to $12.00, a sum which few mechanics, especially apprentices, would care to invest in a single work. But by taking it in parts at thirty cents, many a quarter will be saved which would otherwise be spent for cigars or lager, while the money thus invested will bring in better returns than if it were placed at compound interest. Moreover each part may thus be studied carefully as it is received, and the money need not be invested in any part of the book until that part is wanted. Of course these remarks apply chiefly to our young men, or rather boys who are endeavoring to fit themselves for a future career of usefulness.

Of the character of the work it is hardly necessary to speak. We were familiar with the first edition and held it in very high esteem, and we have no doubt that the author has introduced into this new edition those improvements which a riper personal experience and the general advancement of the art have brought to his notice.—*Manufacturer and Builder.*

FORCE AND NATURE, ATTRACTION AND REPULSION; THE RADICAL PRINCIPLES OF ENERGY, DISCUSSED IN THEIR RELATIONS TO PHYSICAL AND MORPHOLOGICAL DEVELOPMENTS. By CHARLES FREDERICK WINSLOW, M. D. Philadelphia: J. B. Lippincott & Co.

We have endeavored, before expressing our views in regard to this book, to read it in a perfectly candid spirit of inquiry. We confess that we found it hard to maintain that spirit to the end. Its style is at times forcible, and its author has evidently caught more than a mere glimpse of certain fundamental truths; but while saying this much, we are compelled to add that it is one of the most illogical books we ever attempted to peruse. It is full of fantastic speculations, and contains not a few errors in its statements of facts. It is wearisome, from its interminable repetitions and its diffuse method of discussion will hardly fail to draw upon it the severe criticism of thinking readers. In short, it is to philosophy what punch is to the palate, full of incongruities; and, although too much diluted by redundant forms of expression, till quite palatable, but not very nutritious. Claiming at the outset to assume nothing, it ends by assuming everything. Written to enunciate what is evidently a pet theory of the author, namely, that repulsion is equal in quantity to attraction, and that the two are co-existent, and the foundation of all material existence, it will convince few; while its speculations will, if we mistake not, draw upon its author a storm of adverse criticism.—*Scientific American.*

IRON: ITS HISTORY, PROPERTIES AND PROCESSES OF MANUFACTURE. By WILLIAM FAIRBAIRN, C. E., F. R. S., &c. &c. Third edition, revised and enlarged. Edinburgh: Adam and Charles Black, 1869. For sale by D. Van Nostrand, N. Y.

When Mr. Fairbairn gave the pofession a second edition of his treatise on iron and steel manufacture, he predicted that great changes would, at no great distance of time, occur in that department of industrial art, and which would result in the production of a superior article. These changes have, to a great extent, occurred, and have necessitated another edition of Mr. Fairbairn's most useful work, which now lies before us. The verification of this prediction has been chiefly accomplished by the extension of the Bessemer process, and the gradual introduction of the homogeneous system into the manufacture of metals. Mr. Fairbairn describes all the new improvements, including the Heaton process, which, by the introduction of the crude nitrate of soda, results in the production of "steel iron" from any kind of pig iron. This method of manufacture is described in a chapter which embodies the improvements in the manufacture of iron and steel from 1864 down to the present time. The work is fully illustrated, and contains some valuable information upon the properties of the materials of which it treats.—*Mechanic's Magazine.*

EXAMPLES OF MODERN STEAM, AIR AND GAS ENGINES. By JOHN BOURNE, C. E. London: Longmans, Green, Reader and Dyer, Paternosterrow. For sale by D. Van Nostrand.

We have now got half way through Mr. Bourne's work on modern engines, Parts XI and XII being now to hand. In these, as in those which have preceded them, there is no lack of interest. After pointing out the probable course of improvement in locomotives, the author gives a condensed account or recapitulation of the principal classes of improvements in the steam engine, which have been propounded at various times in its history. These are arranged chronologically, dates and the numbers of patents—where patents have been obtained—being given. Thus, independently of the practical observations of the author, we have a very complete index of the subject, which, of itself, will prove of great value to many designers and improvers of steam engines. A large folding plate of Captain Ericsson's original "Monitor," showing the screw and turret machinery, accompanies Part XI, whilst Part XII has two plates, giving the details of surface-condensing engines, by Messrs. Richardson.—*Mechanic's Magazine.*

THE INDUSTRIES OF SCOTLAND. By DAVID BREMNER. Edinburgh: Adam and Charles Black, 1869.

During the last year, a series of very interesting articles upon the industries of Scotland appeared in the weekly issue of the "Scotsman." These articles were fair and accurate accounts of the various

branches of trade, and we are now glad to see them collected together and reproduced in a more permanent form The volume in question is a history of the rise, progress, and present condition of the Scottish industries, especially of those which, by their extent or peculiarity, merit notice. Mr. Bremner judiciously confines himself to a plain narrative of facts, which have been carefully selected, and are interspersed with here and there a few general reflections. Iron works, coal mines, shipbuilding establishments, railway works, linen and cotton works, fisheries, &c., present themselves in turn.—*Mechanic's Magazine.*

A Treatise on the Teeth of Wheels; demonstrating the best forms which can be given to them for purposes of Machinery, such as Mill-work and Clock-work; translated from the French of M. Camus, by John Isaac Hawkins. Third edition. Philadelphia: Henry Carey Baird, 406 Walnut street. Price $3.

The "rule of thumb" has always very extensively governed the construction of toothed gearing, and the consequence is that perfect gearing is very rare in machinery. It is astonishing when we consider the immense saving in friction, wear and cost of repairs, and the greater regularity of operation obtained by the use of gears with properly constructed teeth, that more attention has not been paid to the subject. This little book explains, in such manner as to be intelligible to those who are in the least acquainted with mathematical science, the proper form of the teeth of wheels, and the art of finding the number of teeth which ought to be given to wheels and pinions. It goes very fully into the subject, and is illustrated by eighteen plates of diagrams.—*American Artizan.*

Report of a Special Committee on the Merits of a Proposed Method of Supplying Pure Air to Schools, Churches, Hospitals, Asylums, Dwellings, and all Occupied Houses; also Railroad Cars and Passenger Vessels. Presented at the Regular Meeting of the New York Association for the Advancement of Science and Art, at Cooper Institute, and unanimously adopted, March 8th, 1869.

The pamphlet of which we have just given the title is a singular document—singular for its grammar, and perhaps still more singular from its strange mis-statements of scientific facts.

The "Manufacturer and Builder" thus commences a criticism of some length, and we think it makes out a rather embarrassing case for the unanimous New York Association for the Advancement of Science and Art.

General Problems in the Linear Perspective of Form, Shadow and Reflection: or the Scenographic Projections of Descriptive Geometry. By S. Edward Warren, C. E., Professor of Descriptive Geometry, etc., in Rensselaer Polytechnic Institute. New York: John Wiley & Son, 2 Clinton Hall, Astor Place.

Professor Warren is widely and favorably known as the author of several valuable works on drawing. The present volume ample sustains his previous reputation and must prove not only a most efficient text-book in our industrial schools, but a valuable aid to architects, engineers, and all who have occasion to make accurate drawings.—*Manufacturer and Builder.*

The Millers', Millwrights' and Engineers' Guide. By Henry Pallett. Illustrated. Henry Carey Baird, Publisher, Philadelphia. Price $3 post-free.

This book should be in the hands of every miller. The subject is treated in a plain, familiar manner, free from all unnecessary technical words, and intelligible to those of the most limited education, the general information afforded being almost invaluable to those who have not had an opportunity of judging the best way of milling. The transparent model attached to the work showing the action of the furrows cutting wheat and the operation of the millstones is, of itself, worth the price of the book. It is, perhaps, as full and complete a work on milling as has ever been published, and ought to be read by all engaged in the business.—*Milling Journal.*

A Practical Course of Military Surveying; including the Principles of Topographical Drawing. By Capt. Lendy, F. G. S., etc. With an Atlas, mostly by Maj. Petley. New Edition. London: Atchley & Co. 1869. For sale by Van Nostrand.

That this able work has reached a second edition is a practical and well-merited testimony in its favor. The author is director of the Practical Military College at Sunbury; and Major Petley is Professor of Military Surveying at the Royal Military College, Sandhurst. This edition contains many additional plates, etc. The practical part of the work has not been altered, and remains quite elementary, though deemed sufficient for all field purposes. A brief sketch of the operations necessary for a trigonometrical survey has been added.—*Builder.*

Physical Survey of Virginia; her Geographical Position; its Commercial Advantages and National Importance. Preliminary Report by M. F. Maury, LL. D., etc., Professor of Physics, Virginia Military Institute, Lexington, Va. Second edition. New York: D. Van Nostrand, publisher, 23 Murray street and 27 Warren street.

This work, besides pointing out the advantages which arise from the geographical position of the magnificent State of Virginia, and which are illustrated by large maps, contains very valuable information as to its climate, soil, and productions, its mineral resources, water-power, and manufacturing facilities, and gives valuable suggestions as to how its industry may be stimulated, its enterprise encouraged, the material prosperity of its people advanced, and its general welfare promoted.—*American Artizan.*

The Parks, Promenades, and Gardens of Paris, Described and Considered in Relation to the Wants of Our own Cities and of Public and Private Gardens. By W. Robinson, F. L. S. London: John Murray.

This is a comprehensive and elegant work, profusely illustrated, and of undoubted value to public and private decorators of parks and gardens.

Polar Magnetism: A Paper read before the American Institute on the Cause of Polar Magnetism, the Attraction of the Needle to the Pole, the Variations of the Compass, and the Phenomena Incident to the Same. By John A. Parker. New York: Wiley & Son.

SECOND LECTURE ON POLAR MAGNETISM: ITS ASTRONOMICAL ORIGIN; ITS PERIOD OF REVOLUTION AND THE SYNODICAL PERIOD OF THE EARTH IDENTICAL. READ BEFORE THE AMERICAN GEOGRAPHICAL AND STATISTICAL SOCIETY. By JOHN A. PARKER. New York: Wiley & Son.

These two pamphlets, instead of being a contribution to the stock of public knowledge, are simply an exhibition of the ignorance of the author concerning a subject which appears to have occupied his attention since he published a book of similar calibre, on the quadrature of the circle, some eighteen years ago. This says the reviewer, in the "American Journal of Mining," and he certainly makes out his case, in an article of some length and a good deal of breadth.

THE RESOURCES OF MISSOURI, AND THE NATURAL ADAPTATION OF ST. LOUIS TO IRON MANUFACTURERS. By SYLVESTER WATERHOUSE, of Washington University.

This pamphlet, which was published originally in 1867, has recently been enlarged by an appendix on the adaptation of St. Louis to iron manufactures. It contains much that is interesting. The experiment in manufacturing iron at Carondelet affords the data for Professor Waterhouse's conclusions. In the first place, the quality of the pig iron made there is pronounced good by a number of presidents of companies engaged in manufacturing articles of hardware. As to the cost of manufacturing, the pamphlet goes into elaborate statistics and makes out a good case.

KEMLO'S WATCH-REPAIRER'S HAND-BOOK; BEING A COMPLETE GUIDE TO THE YOUNG BEGINNER IN TAKING APART, PUTTING TOGETHER, AND THOROUGHLY CLEANING THE ENGLISH LEVER AND OTHER FOREIGN WATCHES, AND ALL AMERICAN WATCHES. By F. KEMLO, Practical Watchmaker; with Illustrations. Boston: A. Williams & Co., 100 Washington street.

This little book should be owned and studied by every young watchmaker and watch-repairer; and it is of value to every owner of a watch, teaching him how to take care of his bosom friend.—*American Artizan.*

To which we may add that the little work is elegantly got up and illustrated, being, in fact, an art book as well as a text book.

FRENCH MEASURE AND ENGLISH EQUIVALENTS.—By JOHN BROOK. Sheffield.

In a series of compact tables the English values of French measure are arranged from one to a thousand millimeters, and from one to a hundred meters; the fractions of an inch progressing in sixteenths are also reduced to French values. The little book will be found useful to almost every engineer.

ROADS, RAILWAYS, AND CANALS FOR INDIA. By T. LOGIN, Esq., C. E., &c. London: E. & F. N. Spon.

This is a double pamphlet, full of facts, calculations, and suggestions on this important matter, and will no doubt prove of value to all immediately interested in the development of the economic resources of India if not of America.

BRITISH RAINFALL, 1868: ON THE DISTRIBUTION OF RAIN OVER THE BRITISH ISLES DURING THE YEAR 1868; WITH REMARKS AND ILLUSTRATIONS. Compiled by G. J. SYMONS, F. M. S. London: Stanhope, 1869. For sale by Van Nostrand, New York.

MISCELLANEOUS.

HEAT NECESSARY TO IGNITE VAPORS.—W. R. Hutton, of Glasgow, has recently determined the degree of heat at which the vapors of a number of liquids catch fire from a burning candle, when it approached to the surface of the fluid at a distance of 1.5in. or 0.5in. The results of these experiments are recorded in the subjoined table:

	Specific weight.	Inflaming Point in Degs. of Fah.	
		At a distance of 1.5in.	At a distance of 0.5in.
	Deg.	Deg.	Deg.
Sulphuric ether	747	Below 53	....
Bisulphide of carbon	1.270	do 53	....
Petroleum benzine	706	do 53	....
Benzole from coal tar, 90 per ct.	861	do 74	71
Crude paraffin oil	849	do 74	72
Crude naphtha	884	do 78	74
Whisky	940	do	85
Wood naphtha	9.840	do 87.8	81
Crude paraffin oil	891	do 89	84.2
Crude naphtha	881	do 90	86
Dutch gin	930	do	90
Wood spirit	827	do 96.8	84.2
Illuminating naphtha	859	do 100	91
Wine spirit	817	do 104	73
Whisky, 15 overproof	893	do 109	83
Whisky, 11 overproof	905	do 110	84.2
Kerosene	801	do 118	110
Light oil from coal tar	920	do 119	109
Spirit from resin	922	do 122	105.8
Turpentine	875	do 130	119
Sherry wine	993	do	130
Port wine	1.003	do	130
Refined paraffin oil	809	do 134	123
Refined paraffin oil	814	do 138.2	127
Fusel oil	850	do 140	129.2
Oil from resin	987	Above 212	....
Heavy tar oil	950	do 212	....

STREET WASHING AND SWEEPING.—The following practical remarks were made by Mr. J. K. Fisher before a recent meeting of the Polytechnic Association of the American Institute:

"The superiority of washing streets may be seen by those who observe the following facts:—1st, Fully a third of the dirt is left on the pavement by the machine and hand-brooms in Broadway. 2d, A strong shower washes the pavement clean, excepting where there are holes, in which water remains and sediment falls. 3d, In wet weather the streets are not swept, but mud accumulates for days and weeks; and the mud holds water like a sponge, and keeps the streets wet for days after the sidewalks would be dry, were the mud not tracked upon them. 4th, The best time to wash a street is while it is wet; the washing engine would then use less water. 5th, As soon as rain is over, the washing engines would do their work, and blow the dirty water out of the holes, and leave the pavement nearly dry, so that in half an hour it would be completely dry; thus saving the muddiness, which now lasts from two to six days before the contractor

sweeps. 6th, The cost of washing by hose-jet in Sheffield was less than half the cost of sweeping and cartage; proper washing engines would further reduce the cost. The washing would make less dust than sweeping.

"Considering the mud avoided, and the little if any dust, the washing system would give more than double cleanliness, probably at half the cost of the present inefficient system. The washing engines would be efficient fire engines, and would always be ready to leave their street work instantly when fires occur; their cost would therefore be little beyond what is now incurred for engines and men, who do but few hours' work in a year.

"Floating fire-engines could dredge the docks by jet, while the tide runs outward, and thus clear the docks from the street dirt, and at the same time serve as fire engines better than if kept inactive, without steam up and their fires strong.

"Some of our sewer engineers say that the sewer gullies are not made to pass street dirt, but to catch it; and that, therefore, alterations would be required to make this proposed system practicable. Others say that much of the street dirt does go through the sewers. I am convinced, by evidence published in England, that the system is practicable with the present gullies, and that the gully traps are needed to catch the gravel that is often found in streets, and that might do harm in the sewers. Mr. McElroy's paper is good professional evidence against the hasty surmises of engineers who have not studied the subject."

DATES—AMENDMENT IN THE BRITISH CONSTITUTION NEEDED.—According to English newspapers, technical, commercial and literary, no event ever took place on the 20th of July, or the 11th of December, or at any other period absolutely defined in the statement of fact. "Messrs. Samuda launched the ironclad *Vengeance* on Thursday;" "Mr. Scott Russell yesterday lectured the Royal Institution;" "the John Bull won the ocean race, by arriving on Friday;" "a total eclipse of the sun will take place on Wednesday." In rare instances we are favored with a hint in the shape of "next" or "last," but not by polite writers. The man who hopes to be a F. R. S. would utterly ruin his chances by writing "Wednesday last;" and there is not an engineer's apprentice in Great George street who dares write "Thursday July 1st," in an article intended for publication.

Nicholas Woods, the wonderfully versatile and remarkably accurate reporter for the "Times," who does with equal elegance an armor test at Shoeburyness one day and a marriage at St. George's, Hanover Square, the next; a hanging at Old Bailey in the morning and the trial of a surface condenser at the Isle of Dogs in the afternoon—Woods is a precedent and a pillar in the British Constitution. Woods says in the "Times" that a thing happened "on Thursday," and even Colburn does'nt quite like to add "July 1st," for, independent as he may be in his professional convictions and expressions, an un-Woodsy style of reporting a fact would be as inexcusable a violation of British precedent as traveling in cars that were not locked, or crossing the channel with the decency and comfort of Long Island Sound navigation.

Seriously, this almost universal omission of dates in the English papers is as unnecessary as it is inconvenient. One has to find the date of the paper and compute the time, unless, as is often the case in newspaper offices, one happens to be reading a slip without date; but when a technical weekly or monthly copies *verbatim* from a *daily* about the trial that was completed "yesterday," or the ship that was launched on "Thursday," this affectation of the cockney-daily style becomes ludicrous as well as embarrassing.

SUBJECTS OF BRITISH LETTERS PATENT FOR 1868. Mr. George Shaw has drawn up a condensed analytical list of letters patent for inventions granted and provisional protections applied for during the year 1868. From this summary of inventive effort we subjoin an indication of the progress discernible in materials and appliances connected with building trades. In all, there were 3,991 applications. Of this large number 11 related to improvements or inventions connected with sewers, drains and cesspools; 13 with making and sweeping roads; 38 appertained to wheels for railway and other carriages; 4 to docks, breakwaters, and submerged works; 84 to furnaces and consuming fuel; 116 to railways, locomotives and railway carriages; 185 to steam engines and steam boilers; 33 to artificial fuel, matches and splints; 6 to baths; 4 to bells and bell-hanging; 2 to castors for furniture; 32 belonged to latches, hinges and springs for doors; 5 to fenders, fire-iron and fire-guards; 39 to nails, bolts, screw-nuts, and rivets and machinery for manufacturing the same; 21 related to the processes of sawing, planing, boring, etc., stone and slate; 54 to sawing, planing and turning metals, wood, etc.; 79 to telegraphs, signals and intercommunication in railway trains; 4 to surveying instruments; 14 to drawing, painting, and exhibiting pictures and photographs; 31 to windows, sashes, shutters, doors and fencing; 3 to floors and flooring machinery; 52 to tunnels, bridges, arches and portable and other buildings; 21 to lime, brick, and other kilns and coke ovens; 10 to artificial stone, plaster and cements; 30 to bricks, tiles and clay-pipes; 13 to glass manufacture; 19 to blinds, curtains and shades; 43 to stoves, grates, fire-places, kitchen ranges and culinary apparatus; 30 to warming and ventilating buildings; 11 to gas-burners; 33 to gas and water meters and regulators; 43 to cocks, taps and valves; 31 concerning pipes and tubes for steam, water and gas, and joints for the same; 21 related to water-closets and urinals; 16 to hydraulic machinery for raising and distributing water; 5 treated of the preservation and preparation of timber; and 2 apportioned to coffins, hearses, and preservation of the dead. Satisfactory as this amount of activity thus indicated may be, it appears trifling to that fermenting in men's brains on the other side of the Atlantic.—*Builder*.

THE GUIBAL FAN.—A large fan, on the Guibal principal (see Van Nostrand's Magazine, No. 1, page 43), was recently started at the Byers Green Colliery, and did good work. It was run up to 60 revolutions per minute, and at this speed produced 68,000 cubic feet of air per minute, with a water gauge of 3.10 in. The quantity of air previously got by the furnace was 11,000 cubic feet below the quantity produced by the fan, or 57,000 cubic feet. The fan has not yet been worked up to its maximum power, as it is guaranteed by the maker to work up to seventy revolutions per minute. The makers are Messrs. Black, Hawthorn & Co.. of Gateshead.

LONG SPAN BRIDGES.—Prof. De Volson Wood has furnished the following interesting summary to the "Journal of the Franklin Institute:"

TABLE OF BRIDGES HAVING LONG SPANS.—*Trussed Bridges.*

NAME OF BRIDGE.	Total length in feet.	No. of spans.	Longest span.	REMARKS.
Schaffhausen, Switzerland	365	2	193	Weisbach Mech. vol. II, p. 283.
Trenton, N. J.	880	5	200	Wooden arch trussed. Haupt on Bridge Construction, p. 242.
Columbia, Penn'a.	5,280	29	200	Burr's; destroyed during rebel invasion, 1863. Mahan, p. 240.
Newark Dyke, Eng.	.....	.....	240½	Longest span of Warren's Girder. Jour. Frank. Inst., vol. 26, 3d series, p. 156.
Essex, Mass.	250	1	250	Mahan, Civ. Eng., p. 238.
Chepstow, Eng.	606	4	306	Queen Past—Theory of Bridges—Weak.
Noget, E. Prussia	374½	2	321	Jour. Frank. Inst., vol. 39, 3d ser. p. 230.
Upper Schuylkill	.....	1	340½	Mahan, p. 237.
Louisville Bridge, over Ohio river,	5,201	25	370	Fink's Truss—Report of Committee.
Wettingen, Germany,	390	1	390	Erected in 1778. Longest span of wooden truss on record. Weisbach Mech. vol. II, p. 83.
Dirschau, Prussia	2,383½	6	397½	Iron lattice. Jour. Frank. Inst. vol. 39, 3d series, p. 230.
Kuilmburg, Holland	.....	.....	515	Longest span trussed bridge. Official report, 1866.
Derry, designed by Claus (never built)	.....	1	900	Proposed wooden structure. Weis. Mech. vol. II, p. 84.

Tubular Bridges.

NAME OF BRIDGE.	Total length in feet.	No. of spans.	Longest span.	REMARKS.
Conway, Eng.	.....	1	400	Civ. Eng. Jour., 1848.
Britannia, Eng.	1,513	4	460	Tubular bridges by Dempsey. Traité de la Construction des Ponts Métalliques, pl. X.
Victoria, at Montreal, Canada.	10,284	25	330	Hunt's Merch. Mag., vol. XXXI, p. 504; 24 spans are each 242 feet.

Arched Bridges.

NAME OF BRIDGE.	Total length in feet.	No. of spans.	Longest span.	REMARKS.
Neuilly (over Seine)	*640	5	128	Mahan, p. 225.
Teff, South Wales	. ....	1	140	Failed by rising of the crown. Woodbury on the arch, p. 432.
London Bridge	784	5	152	Woodbury, p. 432—for railr'd purposes.
Rica, Ayr	.....	.....	180	Jour. Frank. Inst., vol. 39, p. 231.
Chester or Grosnover	.....	.....	200	Mahan, p. 228.
Great Washington Aqueduct	.....	.....	200	Sc. Am. 1860, p. 86. Cast iron, by Rennie.
Southwark	.....	.....	250	Smile's Lives, Eng., vol. II, p. 188.
Trizzo Adda	251	1	251	Longest stone arch on record. Treatise on Bridges, Weale, vol. I, p. 48.
St. Louis Bridge	1,509	3	515	Not yet built. The arch to be of steel. Rep. by the Co., 1858.
Proposed bridge over the Thames, by Telford	.....	1	600	To be made of iron. Weisbach, v. II, p. 86.

* More than 640.

Suspension Bridges.

Name of Bridge.	Total length in feet.	No. of spans.	Longest span.	Remarks.
Niagara Carriage Bridge	.....	1	1,264	Sc. Am., vol. XX, p. 218. This bridge is about a mile below Niagara Falls.
Cornwall (proposed to be built across the Hudson river, 42 miles above N. Y. City).....	2,409	1	1,600	Jour. Frank. Inst., vol. LVII, p. 165.

Name of Bridge.	When built.	Span.	Remarks.
Douro, at Oporto	1842	558	Sup. to Weale's Bridges, p. 144.
Menai, Eng.....	1825	580	Chain cable. Mahan's Civ. Eng., p. 255
St. John's, N. B.....	1852	622	Sc. Am., June 19th, 1862.
Nashville, over Cumberland.....	1850	656	Destroyed by rebel Gen. Floyd, Feb 1862. Sc. Am. Mar. 30th, 1850.
Pesth, over Danube	1849	670	Total length, 1250. Jour. Frank. Inst., vol. XVII, 3d series, p. 300.
Niagara Railroad Bridge.....	1854	822	Jour. Frank. Inst.
Fribourg, Switzerland.....	1834	870	Jour. Frank. Inst., vol. XXIII, 2d series, p. 141.
Lewiston (7 miles), below Niagara Falls ..	1856	1,043	Sc. Am., June 1st, 1861. Blown down Feb. 1864.
Lexington and Danville Railroad Bridge...	1856	1,220	Jour. Frank. Inst., vol. XXXIX, 3d series, p. 230.
East River Bridge, N. Y. City.....	.....	1,600	Proposed. Jour. Frank. Inst., vol. LXXXIV, p. 243.

Root's Pressure Blower.—This device is now, by general consent, here and in England, one of the best, if not the very best means of blowing cupola furnaces. A pair of reciprocating pistons afford, of course, a steady blast of any desired pressure; but they are costly to construct, and the piston packing and valves are subject to wear. No fan blower can be depended upon to give the requisite pressure, viz: half a pound to a pound per square inch—a pressure indespensable to continuous melting, as in the Bessemer manufacture. Rotatory blowers with sliding pistons or rubbing surfaces of any kind, may indeed be kept tight if constructed with sufficient cost, and carefully cleaned and lubricated. The advantage of Root's rotatory blower is that it has, strictly speaking, no rubbing surfaces. The floats, or rotatory pistons, are so shaped that the projections of the one exactly fit into the hollows of the other, without the need of sliding vanes. There is of course a very thin space between the floats, through which a thin film of air leaks back, but this loss is reduced to a minimum by means of a stiff paint or plaster of black lead and tallow, which is applied to the floats and soon moulds itself to fill the spaces that would otherwise promote excessive leakage. But, as in all other machinery with which we are acquainted, the best materials and workmanship pay best in the long run. The shrinkage or the loosening of the wood forming the floats, by reason of improper seasoning or fastening, soon cause excessive friction as well as leakage. Perfectly seasoned wood floats, secured as well as they *can* be to steel shafts and cut gearing, certainly answer well; this we know from experience with not less than three of these blowers, of the largest sizes. At the same time, we think the extra cost of cast-iron floats, planed or dressed by special tools and gauges to a perfect fit, and revolved by several sets of wide-faced cut gears, so as to avoid back lash and wear, would pay. The power wasted in driving a noisy or leaky blower, would cost more than the most accurate construction.

Elastic Collodion Cement.—Ordinary collodion is made by dissolving eight parts of gun-cotton in one hundred and twenty-five parts of ether and eight parts of alcohol. When used as a cement or varnish it becomes very hard, cracks easily, and peels off. It may be rendered elastic by the addition of four parts of Venetian turpentine and two parts of castor-oil. When intended for surgical purposes, as a varnish, which when dry forms a perfectly close-fitting plaster, it has been found that the addition of some glycerine to the ordinary collodion, in which it is dissolved to a small extent, makes a varnish which adheres strongly to the skin, does not crack, and, on account of its elasticity, does not crease the skin.

Wire-Rope Transport.—The practical value of the wire-rope transport system, invented by Mr. C. Hodgson, C. E., (see V. N's. Mag. Vol. I, p. 334,) is now being recognized by those engaged in working mines. Sir G. S. Robinson has given an order to the Wire Tramway Company to construct one of their patent ways, for carrying iron ore from his quarries to the Cransford Station.

ARTIFICIAL STONE.—Mr. Hodgsol, the proprietor of four patents on artificial stone, exhibited his process for manufacturing this stone at a late meeting of the Polytechnic Association of the American Institute. The stone consists of sand cemented together by means of oxalate of lime. The inventor takes two or three parts of sand to one of lime, or rather lime slacked with a solution of oxalic acid. The materials are carefully mixed and then pressed in a mould, where they quickly set. The articles are then transferred to a bath containing a solution of oxalic acid, where in a short time they become hard. Oxalic acid forms with lime a compound of great insolubility. Indeed, the oxalate is the most insoluble of all the salts of lime. A great deal has been said about the superiority of the cements made by the ancients. This is due partly to the influence of time, and partly because the poor cements have disappeared. When lime and sand are left in contact for many years a chemical union takes place, and a true silicate of lime is formed. Hydraulic cement requires the presence of alumina. The Rosendale cement contains carbonate of lime with silica, alumina and magnesia. The French, in making the Suez Canal, employ the mud of the lakes, the sand of the desert and lime, which they mix, bake in the sun and use for the construction of piers, etc., without the application of any fire. This stone is about equal in hardness to Cayenne stone.

ELECTRO-MAGNETIC ENGINES ON BOARD SHIP.—Mr. John Tawse writes to "The Engineer" as follows: Some years ago, when in India, I had a boat on one of the salt lakes of the Coromandel coast, and from experiments I then made I became impressed with the idea that there is an immense mechanical power lying dormant in the simple and natural *galvanic action of salt water on the sheathing of vessels*. Electro-magnetism has hitherto failed as a motive power on the score of economy only. The form of battery used is too expensive, owing to the use of strong acids acting upon a comparatively small surface. Also in this case the electric current is deficient in quantity for mechanical purposes. What seemed to be wanted was a very large area of metallic surface, acted upon by an excitant strong enough to evolve a powerful current, yet not sufficiently so to wear or corrode the plates in a very perceptible degree. I have since published the idea which this gave birth to in several of our scientific journals. But as I have now worked it out to completion, both by calculation and experiment, I detail it herein for the information of your readers.

A vessel to be fitted with an electro-magnetic engine attached to an ordinary shaft, is sheathed on one side with copper, and on the other side with zinc. The sheathing is laid on over sheets of gutta percha in order to insulate it from the woodwork of the vessel. The nails necessary for this purpose are driven in such a manner that they are nowhere in metallic contact with any part of the sheathing. The two sections of copper and zinc sheathing thus form a battery, acted upon and excited by salt water alone. If any one acquainted with the subject will calculate the result of galvanic action on so large a surface as the area of immersion of a floating vessel, they will perceive that it is the right application of it alone that is wanted to convert it into a powerful mechanical force.

The vessel being so sheathed, a wire from each section of course conducts the current to the electro-magnetic engine. In my first experiments I had a large magnet to work a keeper in connection with a crank in the usual way. Since then I have adopted a mode of multiplying the power enormously. Thus the wires are connected with a thick, small-sized electro-magnet in the first instance. In front of its two poles an armature is made to rotate with great velocity, and the augmented current thus produced is carried to an arrangement of two very large magnets working reciprocally in such a way that the keeper, or soft iron beam between them, which works the crank axle of the screw, flows the current into each separately at every stroke, charging it just before the moment of contact. As regards the wear of the plates, it would be no greater than in the case of ordinary sheathing, with this advantage, that no sea-weed or barnacles would adhere to sheathing in constant galvanic activity; ordinary copper sheathing would be quite free from them if the galvanic circle were complete. In fitting the above engine to a vessel the rotating armature working before the first magnet would have to be driven by a small steam engine.

ON THE COST OF WATERWHEELS IN ENGLAND. Mr. Robert Sanders writes to the "Mining Journal" as follows: After fifteen years' practical experience in working all kinds of mining machinery by waterwheels, I am prepared to assert that a wheel 10 ft. in diameter, 3 ft. breast, should not cost about 10*l.*; one of 24 ft. diameter, 4 ft. breast, 120*l.*; or one of 40 ft. diameter, 3 ft. breast, 220*l.* I will quote one instance just to show something about the price of waterwheels. At the Carmarthen United Lead Mines, in South Wales, I had two wheels erected, one of 34 ft. diameter, 3 ft. breast, with cast-iron axles, centers and shrouding; the arms, soling and buckets were of yellow pine; there were also the crank-pin and connecting-joint for sweep rod. The other was 24 ft. diameter, 4 ft. breast, with cast-iron axle centers and shrouding; the arms, soling and buckets were of red, or pitch, pine; also crank-pin, connecting-joint, etc. Both of these wheels were made per contract. The cost of each, including erection, was as follows: 34 ft. diameter, 164*l.* 10s.; 24 ft. diameter 119*l.* 10s. The latter, including wheel-pit, etc., when ready to work, cost altogether 144*l.* The former had no wheel-pit, but worked on a frame, like a grindstone, made of American pine log, and the whole expense when ready to work did not exceed 230*l.*

HOW TO TEST THE LUBRICATING POWER OF OIL. It is a matter of importance to the mechanic to be able to say what amount of friction a particular oil can overcome as compared with another oil. This is done by an apparatus called an "oil-tester," of which a new form, devised by Mr. T. R. Shaw, is thus described: On a vertical shaft fitted in bearings is fixed a disc, on the upper surface of which rests a circular or partly circular block, the two surfaces in contact being preferably finished as true plans. The lower disc is caused to revolve rapidly by suitable means, the continued rotation of the block being prevented by a cord, one end of which is attached to the side of the block, the other end being attached to a spring balance, or to a weighted and gradual lever. The block is kept in position

on the revolving disc by means of anti-friction bowls, which are so applied as not to interfere with the rotation of the block. A thermometer is fixed in the center of the block. A small portion of the lubricant to be tested is applied to the disc, the metal block is placed in position, and the lower disc is caused to revolve until a certain temperature which has been fixed upon as suitable for all seasons, as for example 70° Fahr., is indicated by the thermometer, when the test of the oil is commenced by noting the frictional resistance indicated on the scale of the spring balance, readings being taken from the scale at intervals during the continuance of the experiment.—*Scientific Opinion.*

THE VELOCIPEDE AS A MECHANICAL AGENT.—The practical value of the velocipede as a means of locomotion has been thoroughly discussed in a well-considered paper by Mr. Lauder, C. E., read before the Liverpool Polytechnic Society. As advantages and disadvantages of bicycles, tricycles, etc., are very equally balanced as compared with each other, Mr. Lauder's conclusions may be considered to apply equally to all kinds of velocipedes. The velocipede possesses *no* advantage; that is to say, a man can, with equal exertion, walk or run quite as far in a day of eight hours as he can travel with a velocipede in the same time. Mr. Lauder, being a velocipedest himself, has given the velocipede all the advantage in the argument that was at all possible; yet he can only show that, although for a journey of a few minutes duration a speed of 24½ miles per hour may be obtained, no more than 30 miles in the day of eight hours can be traversed. Mr. Lauder is of opinion that, as a means of traveling, the velocipede has very little chance of coming into use, although as an instrument of healthful exercise it is worthy of consideration.—*Builder.*

SPEED IN TRAVEL.—In a single second a snail travels one five-thousandth of a foot; a fly five feet; a pedestrian, at ordinary gait, five and three-tenths feet; a camel six feet; an ordinary breeze ten feet; a rapid running stream twelve feet; a trotting horse twelve feet; a whale twelve and three-tenths feet; a fast-sailing ship fourteen feet; a reindeer, with sledge, twenty-five feet; a locomotive engine twenty-nine feet; a skater thirty-six feet; a race-horse forty-one feet; a tempest fifty feet; a swiftly thrown stone fifty feet; an eagle ninety-five feet; a carrier-pigeon four hundred and eleven feet; a rifle ball one thousand five hundred and ninety-five feet; a twenty-five pound cannon ball two thousand two hundred and ninety-nine feet; a point of the earth on the equator two thousand four hundred and fifty-one feet; the center of the earth around the sun four miles; a ray of light one hundred and ninety-five thousand miles.

ATMOSPHERIC SIGNAL FOR SHIPS.—Messrs. MacIver and Co. have introduced Messrs. Wier and Co.'s atmospheric telegraph signals into the Scotia and other large steamers of their fleet. The apparatus may be briefly described as consisting primarily of a small air-chamber to which air has perfect access. In this chamber an elastic disc is placed which, acted on by a lever, compresses the air in the chamber and propels it through a metallic tube of small diameter to any part of the ship with which it is considered desirable to communicate. The air so propelled rings a signal bell in the first instance to secure attention to the signal transmitted; the action of the transmitted air at the same moment that it strikes the bell lifts a small and delicate opaque shutter, revealing under it the word or words of the intended order. The chief point where directions must be given is the locality in which the commander of the vessel is placed, such as the bridge in the case of an ocean-going steamer. Here the handle of the instrument is placed, the whole revolving on a pivot, so that the handle is pressed down to the point which will indicate at a distance the command issued. This is guided in the mode of working by a dial inscribed with the words intended to be communicated.

PROPOSED CANAL BETWEEN THE BAY OF BISCAY AND THE MEDITERRANEAN.—The project of establishing through the Valley of the Garonne (France) a canal for large navigation has often been mooted; but there is now a new plan for this undertaking, under the auspices of M. Staal de Magnancourt. The proposed canal will admit not only merchant ships of the heaviest tonnage, but also men-of-war and transatlantic steamers. A port is to be established in the Gironde, just below Bordeaux, and another on the Mediterranean. The cost of the scheme is estimated at 442,000,000f., and the cutting of the canal would occupy six years. The plan, if carried out, will materially shorten the navigable communication between England, the north of Europe, and India, for it will in fact be a continuation of the canal of Suez.

THE FAST VOYAGE OF THE SCOTIA.—The Cunard mail paddle-steamer Scotia still continues to maintain her supremacy on the Atlantic. Her last passage from New York to Liverpool was one of the shortest on record, she having made the run to the Mersey, including detention at Queenstown, but allowing 4 hours 40 minutes for difference of time, in 9 days and 19 minutes. She had S. S. W. wind on the day of sailing and afterwards moderate easterly breezes throughout. On the 13th she had logged 254 miles, 14th 326, 15th 330, 16th 322, 17th 31, 18th 641, 19th 340, 20th 320, 21st, to noon, 339, being an average speed of nearly 14 knots an hour. The engines of the Scotia are of great power, and with moderate winds she leaves all competitors far in the distance. The Inman screw steamer City of Paris and the Cunard screw steamer Russia are the only two ships which at all approach her in point of speed.—*Engineering.*

IRON SHIP BUILDING IN NEW YORK.—An estimate was recently obtained by a New York shipping firm, for the building of a first-class iron sailing vessel in this country, but it now appears that the vessel is to be built in New York, more favorable terms having been obtained there, and that only the wire rigging, anchors and chain cables, are to be supplied from England. This, we understand, will be the first American built iron sailing vessel to cross the Atlantic.—*Mechanics' Magazine.*

NEW FAIRBAIRN ENGINES.—The Fairbairn Engineering Company have now in hand, and will be shortly ready to exhibit, a set of 60-horse engines, constructed upon an entirely new principle, which, besides possessing other important advantages, will consume probably less than half the quantity of coals required by the best steam engines at present in use.—*British Enthusiast.*